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Teaching Methods, Aids, Apparatus, and Suggestions: Commercial Material for Science Classes. Dufton Distilling Column for Preparation of Absolute Alcohol. Reflex Furnace Reduction of Oxides. A Practical Apparatus for Determining Molecu-

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lar Weights by the Boiling-Point Method. Toy Balloons and Filtration. A Continuous Extractor. Determinations of pH Simplified by Permanent Color Standards. A Laboratory Book Support. Visual Education in the Museum of Science and Industry. The Status and Trends of Visual Aids in Science. **Keeping Up with Chemistry:** Succinchlorimide. Spray-Gun Insulation. Fused Quartz Laboratory Apparatus Made by New Methods. Using Heat to Make Ice. A Substitute for Arsenic. Carboloy—A New Tool Material. The Vitamin Content of Mung Bean Sprouts. The Calcium of Cheese. Counting the Atoms and Electrons. The Production, Properties, and Uses of Zinc Oxide. Cast Iron Is Looking Up. Glycerin and Its Substitutes in Industry. Mohave Desert as a Source of Potash. Mining Gold at the Central Eureka in California. The Field of Photochemistry. Problems in Radioactivity. The Story of Sugar from Flowers. Utah's Beet-Sugar Industry. **Historical and Biographical:** New Pasteur Memorial. Harry Nicholls Holmes. Joseph Priestley, the Clergyman-Scientist. Leo Hendrick Baekeland. Lucius Pitkin. Svante Arrhenius. Memorial Address on Justus von Liebig. Alessandro Volta. **Educational Measurements and Data:** A Study of General Science Textbooks. An Experimental Investigation of the Relative Effectiveness of Two Plans of Supervised Study. **The Methods and Philosophy of Education:** Creating a Curriculum for Adolescent Youth. The Place of Theory in Education. A Study of the Disciplinary Problems and the Method of Handling Them as Practiced in the Senior High School. Are Our High Schools, Colleges, and Universities Meeting Present-Day Requirements? The American Alternative to Examinations. The Principal Studies His Job. The Teaching of Science. A College Course in General Science. Measurement and Experimentation in Educational Methods. A Study of a Modified Form of the Multiple Response Test. Creative Thinking. **The Philosophy of Science:** The Language of Science. Interpretation of Research. **The Teaching Profession:** Grading the Professor. The Advancement of the Professional Training of Teachers. Tentative Plan for New State Retirement Fund. Good Chances for Long Life. Practices Affecting Teacher Personnel. How to Apply for a Teaching Position. "Standards" and the Teaching Load in Sciences. The Training of Science Teachers. **Miscellaneous:** What Is Wrong with the United States? Something for Nothing.

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NOTICE TO AUTHORS OF PAPERS

1. Forwarding Address. Papers intended for publication in THIS JOURNAL should be submitted to Neil E. Gordon, Editor, The Johns Hopkins University, Baltimore, Maryland.

2. Manuscript. The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

3. References and Footnotes. Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

4. Illustrations. Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

Photographs should have a gloss finish and should be at least post-card size—larger, if possible. Only prints which are unblurred and which show sharp contrast between light and dark areas can be satisfactorily reproduced.

Line drawings should be carefully prepared on plain white drawing paper or blue drawing cloth, twice or three times the size desired in the printed cut; it is convenient, when permitted by the scale required, to have them the size of the manuscript. When coördinate paper is used, it should be printed in blue only, with the important coördinate lines ruled over in black; the black square should in general not be less than ten millimeters on a side; the lines of the curves should be the heaviest, except the frame; points on the curves should be indicated by true circles, not crosses. The numbering of the coördinate axes, the number of the figure and any necessary explanations of the figure should be written in pencil in the margin of the sheet, as they are usually set up in type rather than reproduced from the drawing. All lines, numbers, and letters that are to be reproduced are to be so proportioned that they will be clearly legible in the cut.

Tables should be inserted in the body of the manuscript at the proper place.

All photographs, line drawings, and tables should be provided with self-explanatory titles or legends. Each illustration should be marked in pencil on the margin with the name of the author and the title of the article to which it refers.

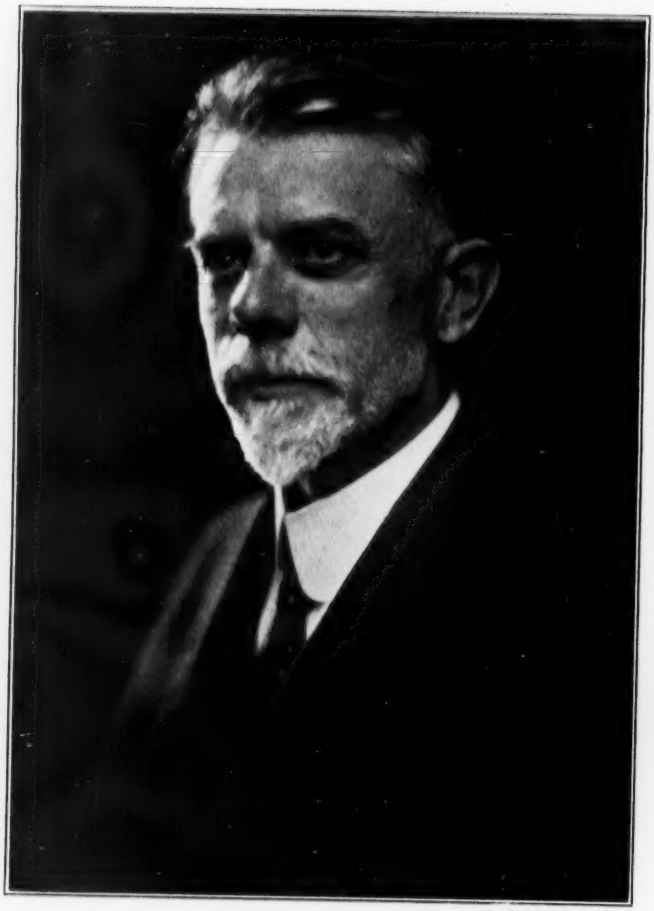


Photo by Bushong

DR. CHARLES A. KRAUS

EDITOR'S OUTLOOK

Charles A. Kraus

IN 1894 Charles A. Kraus matriculated at the University of Kansas as a student. His training there in chemistry was quite limited as regards the college curriculum, the elementary course being the only one which he completed. His primary studies were in physics, mathematics, and engineering, and in 1898 he was graduated from the university with a B.S. degree in electrical engineering.

The desire to find out how and why certain phenomena take place appeared early in his student days. When only a junior in college, he became interested in the conduction process of electricity in metals. His curiosity led him to the literature to learn as much as possible about the metallic state of matter. His desire to study problems in the laboratory at once became apparent. He first worked with Dr. Franklin on the properties of ammonia solutions. Qualitative experiments were carried out as regards the solvent properties of ammonia and later a considerable amount of work, quantitative in nature, on the conductivities and other physical properties of solutions of acids, bases and salts in liquid ammonia was completed. Much of this work was carried out before Kraus received his B.S. degree. The work with Dr. Franklin on ammonia solutions opened an entirely new field of research. Both of these pioneers in the field have been steadily engaged for thirty years in following various lines of attack related to the early experiments, and many other investigators have contributed at times with allied researches. The success of the original experiments was due in a great measure to the extraordinary skill of Franklin in the construction of the apparatus. Dewar flasks, stop-cocks, pumps and all the connecting parts of the various types of apparatus designed for the problem in question were constructed, since nothing was available on the market at that time. Kraus soon became an excellent glass-blower and laboratory experimenter.

After graduation at Kansas, Kraus went to the University of California as an instructor in physics. He continued his research there in the field of physical chemistry but soon left the institution. His next step took him to the Johns Hopkins University where he was appointed a fellow in the department of physics. At the end of the year he changed to the Massachusetts Institute of Technology and was associated with A. A. Noyes and his school. He remained at this institution until 1914, during which time he continued his research on the properties of metals dissolved in liquid ammonia. Many other problems attracted his attention during this period, which served as a foundation for many years of fruitful research. In 1908 he received the degree of Ph.D. from

M. I. T. and was made a research associate in physical chemistry. He was promoted to an assistant professor of physical chemical research in 1912. In 1914 he was called to Clark University as professor in chemistry and director of the research laboratories. After being connected with this institution for ten years, he accepted the appointment of research professor at Brown University in 1924.

In all of his investigations Kraus has shown himself to be an exceptionally gifted experimenter. Many of the problems which he has studied have been completed primarily due to the fact that he possesses originality and ability in the construction of apparatus for the particular problem in question. When considering a problem to be investigated, he designs the apparatus for the problem so that it is simple and efficient. His experimental ability has been mentioned by Lewis and Randall in their text on thermodynamics. In their discussion of the electrode potentials of the alkali metals they say, "The discovery that ethylamine had approximately the desired properties was due to the investigations of Kraus, and it was his extraordinary experimental skill which made it possible to obtain for the first time the electrode potential of a highly electropositive metal, and with a constancy and reproducibility exceeding any that has hitherto been obtained with any electrode of solid metal."

That desire to know the truth concerning physical and chemical processes of nature has always been the predominating factor in his work. Highly speculative theories have attracted his attention but little; he is always interested first in what happens. His research is carried out with zeal and persistence. He is so interested in the work which he and his students are doing that little thought is ever given to anything else unless it is of the utmost importance. Combined with this desire to know the truth, persistence and an unlimited amount of energy to carry on investigations, is the kindly, encouraging attitude he displays toward all those who are associated with him. The student wants to do his best at all times and soon attains the spirit of research.

Dr. Kraus is always closely associated with all the problems that are being carried out by his students. He sees each of them every day to make suggestions that are helpful and follows closely and with interest the progress each one makes. Very often he may be seen in the laboratory working with a student late into the night in order to complete some operation that requires many hours. The close contact with him which all of his students enjoy has contributed a great deal toward their training for future work. His contention that students learn more by actually doing something with their hands has been sustained in many instances.

His entire academic life has been devoted primarily to the training of

graduate students in chemistry. Along with his unusual ability to train students in the laboratory is his success as a teacher. His students will always remember his courses in theoretical chemistry in which he clearly presents the fundamental principles of thermodynamics. He shows originality in his presentation of advanced inorganic chemistry, properties of metals, and the phase rule.

Dr. Kraus is the author of a book on the "Properties of Electrically Conducting Systems" and of over sixty journal articles on chemistry, and has taken out, either alone or jointly with others, more than twenty patents. He is a member of the National Academy of Sciences, the American Academy, the Washington Academy, and Sigma Xi. He was the recipient of the W. H. Nichols Medal in 1923.

Withal, he is a constant attendant at chemical meetings, smokers and like informal gatherings, where he frequently indulges his fondness for card games. A small farm at Princeton, Massachusetts, affords him occasional recreation, which he takes by working as hard on the farm as he ordinarily does in the laboratory.

Concerning the Journal

THE JOURNAL OF CHEMICAL EDUCATION has now published its fifth annual index, and herewith begins its sixth volume. Since the commencement of its second year, when the financial support of the Chemical Foundation made possible a considerable expansion in volume, the JOURNAL has been committed to a policy of "constant improvement, but no annual models." Such alterations and additions as have been made since that time have been adopted at irregular intervals as their advisability and possibility have become apparent. The beginning of a new volume therefore marks no outstanding epoch in the life of this publication; it is but a milestone on the road to the goal toward which we strive.

One of the considerations which first directed attention to the need for such a journal was the desirability of a medium of permanent record for the papers delivered before the Division of Chemical Education of the A. C. S. Perhaps even more important is the corollary function of transmitting the benefits of those meetings to a much larger audience than could ever hope to enjoy their benefits at first hand. Numerous other sources have furnished additional papers of merit on the teaching of chemistry.

The editorial staff of the JOURNAL has always been disposed, however, to interpret the term "chemical education" in its broadest sense, and to publish many papers which do not deal directly with the teaching of

chemistry at all. Articles of this type have included biographical, historical, and philosophical essays, reviews in special fields of chemistry, and descriptions of the application of chemical principles to practical affairs. Originally, this course was dictated by the belief that the average teacher would prefer to direct some of his professional reading toward the ends of enlarging his general background and of keeping abreast of contemporary developments in chemistry, rather than to devote it exclusively to strictly pedagogical problems. That belief has been confirmed in the opinions expressed to us from time to time by many teachers.

Incidentally, the inclusion of non-pedagogical papers has enabled the JOURNAL to serve a much wider audience than had originally been anticipated for it. It now finds its way monthly to the reading tables, not only of teachers of chemistry, but of students and of business and professional men in all lines of endeavor. This expansion of appeal has come about without any sacrifice of fundamental objectives. It has been a product of growth, rather than of compromise or substitution. It will be the aim of the JOURNAL to continue to serve its non-teaching readers, and to serve them better, without in any way neglecting or limiting the pedagogical material offered.

In line with this policy of increasing its field of usefulness was the recent inauguration of the Chemistry Student section. The new section is as yet an experiment in two senses of the word. First, it has still to justify its existence, and second, it has yet to emerge from its present amorphous and tentative state and assume definite form. The process of evolution which this department is undergoing will be strongly influenced in its course by the suggestions and comments of readers.

The Chemical Digest and Abstract sections have been further modified with a view to increased utility. Descriptions of apparatus are accompanied, whenever possible, by illustrative cuts. Abstracts are now grouped under several general headings to enable the reader to locate quickly those items in which he is likely to be most interested. We have as yet discovered no formula which can absolutely assure completeness and accuracy. Constant vigilance and effort are expended toward that end, however.

In accordance with a suggestion from Secretary R. A. Baker, of the Division of Chemical Education, the Recent Books section will publish each month a list of the chemical books received by the Library of Congress during the preceding month.

The general program for the present year may be summed up in brief by saying that it includes no revolutionary departures from past practice. As heretofore, possibilities for improvement will be seized and tested as they present themselves.

MAKING POLLEN EXTRACTS FOR THE TREATMENT OF HAY-FEVER*

EDGAR B. CARTER, SWAN-MYERS CO., INDIANAPOLIS, INDIANA

The physician treats the ailments of mankind, and in the practice of his art utilizes the principles evolved by many sciences. In administering remedies he calls heavily upon those who have been trained in different sciences, that he may have the best that they have been able to produce.

In the utilization of pollen extracts for testing and treating hay-fever patients, the physician calls upon the botanist to collect and certify to the purity of his pollens, the chemist to prepare the stable and potent extract, and the bacteriologist to render it sterile and to vouch for the sterility of the individual containers in which it comes to the physician.

After Duke, Courtesy of C. V. Mosby Co.

AN EXAMPLE OF AN INSECT-POLLINATED PLANT

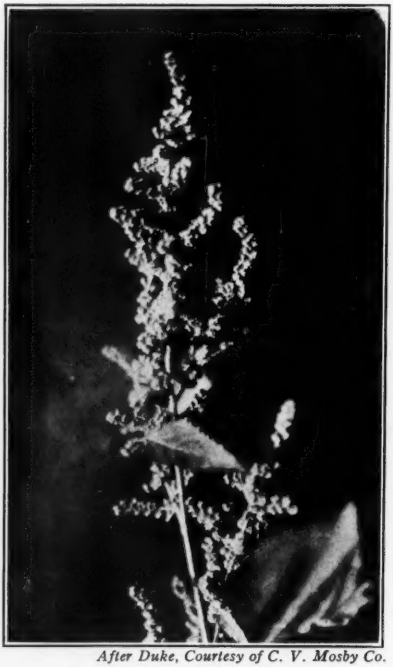
It was the botanist who helped in the beginning to classify the pollens that cause hay-fever. It was the botanist who helped demonstrate the fact that only the pollen of the wind-pollinated plants could cause the intense symptoms of hay-fever sufferers. In other words, the insect-pollinated plants do not cause hay-fever.

Among the flowering plants the ones that are commonly of interest to men are those that are attractive, and because such plants are characterized by color, perfume, or nectar, they are likewise attractive to insects, which in their visits from flower to flower carry on their bodies the pollen or "yellow dust" and thus assure fertilization of the flowers, the reproductive organs of the plant.

The pollen of such insect-pollinated plants is always heavy and sticky, and is never found in the air in appreciable quantities. Thus, it has been said that none of the pollens from insect-pollinated or the attractive flowers are ever the cause of perennial hay-fever. This eliminates from the phy-

* This in substance is the material offered as a part of the program in the General Conference on "Chemistry and Health," Aug. 10, 1928, at the Northwestern University session of the A. C. S. Institute of Chemistry.

sician's consideration, and largely from the consideration of the botanist gathering hay-fever pollens, the pollen of goldenrod, roses, and all garden flowers. It is true that there are hay-fever patients in whom sneezing is produced by close contact with blooming goldenrod, roses, etc., but such sneezing attacks are quickly cleared up as soon as the patient leaves the vicinity of the flowers.



After Duke, Courtesy of C. V. Mosby Co.

A WIND-POLLINATED PLANT

Camera Actually Caught the Cloud of Pollen Thrown off When the Stalk of the Plant Was Struck.

Only Air-Borne Pollens Cause Hay-Fever

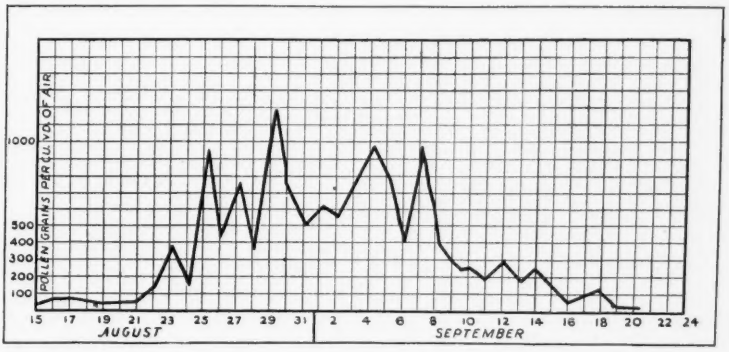
But, we have another kind of flower—a flower usually so insignificant that it is hardly considered to be a flower by any one but the botanist. Such flowers are usually very small. They have no petals, no attractive color, contain no nectar or perfume, and are just as insignificant and uninteresting to insects as they are to man. Such common and unattractive plants must make up for their lack of charm and in some way provide that their pollen may be carried to the pistil of other flowers of similar species. They can hardly hope for insect visitation, and they must shed their pollen into the air in such an abundant quantity as to assure the fertilization of the species. Frequently, the male and female parts of these flowers are on entirely separate plants (*e. g.*, cottonwood, mulberry, hemp, etc.).

The hay-fever plants then are characterized by unattractive and insignificant flowers: but their pollen is so dry and fine, and is shed into the air in such abundance that during the hay-fever season the atmosphere may contain as high as 5000 granules of pollen to each cubic yard of air.

Pollen Content of Air May Be Estimated

It is of interest to know that the amount of pollen in the air at any one time or any one period, may be estimated with some degree of accuracy. The ordinary glass microscope slide is covered with a thin film of oil and is

exposed on a flat surface to the air, usually for a period of twenty-four hours. The slide is then examined under the compound microscope, and the pollen grains are counted over a definite area of the slide. From this number of pollen grains in the measured area, it is possible to estimate according to the law of falling bodies the number of pollen grains in each cubic yard of air during a twenty-four hour period. Another procedure makes use of an ingenious device that has been developed for counting dust particles in the air. This apparatus permits the oiled slide to be swung in a circle and at the same time rotates it edge over edge to avoid deflecting the air through which the slide is swinging. From the number



THIS IS A TYPICAL SEASONAL RECORD OF THE RAGWEED POLLEN IN THE AIR
The counts at Indianapolis go much higher and at Oklahoma City the curve goes to an even greater height.

of pollen grains on a given area of the slide, it is possible to estimate the amount of pollen in the air at any time of the day or night.

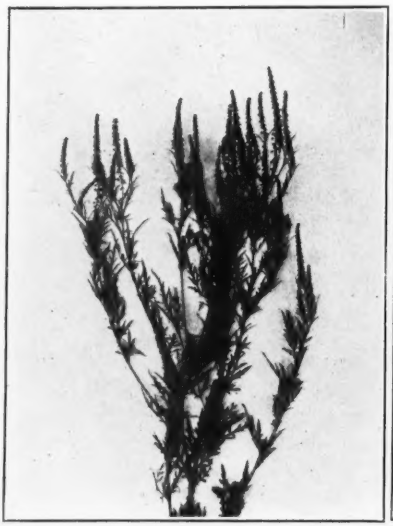
Such estimation of the pollen content of the air is not only interesting, but it has a special field of usefulness to the physician who must desensitize hay-fever patients. From pollen surveys made by botanists especially trained in this work, the physician may know just when to expect the greatest amount of pollen in the air. He will know the kind of pollen in the air, and he will know the periods at which the victims' symptoms are apt to be most severe.

Pollen surveys made in different cities show that there is considerable difference in the concentration of the pollen in different geographical areas. Surveys made at great heights with the airplane indicate that a concentration of pollen sufficient to cause hay-fever symptoms may exist up to one mile above the earth's surface. The air-borne pollens drift for many miles in the wind, and here in Indianapolis we find the pollens of the southern

pines on our slides six weeks before any of the pine trees in the state begin to pollinate.

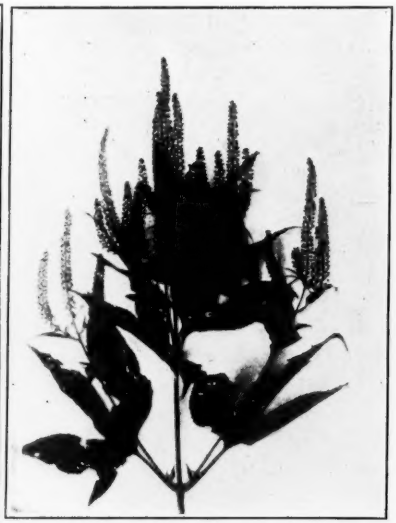
Hay-Fever Seasons Coincide with Pollination of Certain Plants

Most hay-fever patients experience their symptoms in the latter part of August and the first part of September when the ragweed pollens are in the air. There is a small number of people, however, who have hay-fever in June and July when the grass pollens are in the air, and there is a still



SHORT OR COMMON RAGWEED

Because of its wide distribution, its rank growth and abundant pollen, this plant is the most common cause of hay-fever symptoms throughout the United States.



After Duke, Courtesy of C. V. Mosby Co.

GIANT RAGWEED (HORSE WEED)

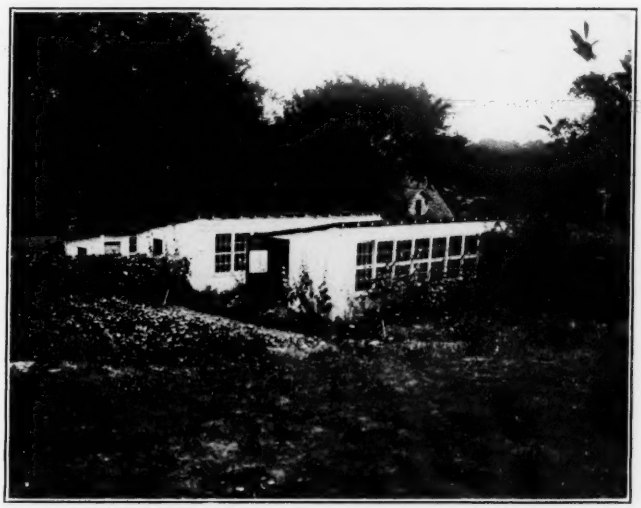
About as common as the Short Ragweed and nearly as important as a cause of hay-fever.

smaller number who experience hay-fever symptoms in the early spring when the trees are pollinating. Farther south where the mountain-cedars pollinate in the middle of winter, it is not unusual to find a few individuals who experience very distressing hay-fever symptoms at that time.

The botanist, then, collecting pollens for the preparation of pollen extracts that are to be used by the physician, has almost a year around job. From early spring until late fall he must do his collecting in order that the physician may have available the extract of any particular pollen which may apparently have some bearing upon the symptoms of any particular individual.

In collecting these pollens it is desirable that the pollen be allowed to ripen in the flower under conditions approximating that which actually takes place in nature. Just as the pollen is ripening, the flowering heads

COLLECTING POLLEN-BEARING WEEDS

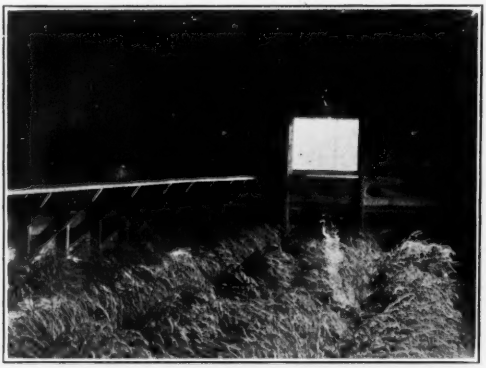


HOUSES FOR HARVESTING OF THE POLLEN

are clipped in great numbers. These are brought into the pollen houses and the stems of the "bouquets" are placed in water at such an angle that the flowering sprays extend out over sheets of glazed paper. The pollen

houses are built to admit an abundance of sunshine and a reasonable amount of fresh air is provided through special ventilators that prevent drafts. Only one kind of plant is placed in a pollen house at a time and the interior must be thoroughly cleaned before the next species is brought in. After several days the pollinating process has been completed and in the quiet atmosphere of the pollen houses the pollen gravitates to the sheets of glazed paper beneath.

The pollen on the papers is swept up with camel's hair brushes passed through 200-mesh sieves to remove extraneous dirt, and is spread in thin layers to dry in an oven at a temperature of 100° F. From the oven of the pollen houses the golden dust goes to the chemical laboratory where it is placed in large desiccators and thoroughly dried over sulfuric acid.



After Duke, Courtesy of C. V. Mosby Co.
INTERIOR OF POLLEN HOUSE WHEN FULL OF FLOWERING TOPS

Making Pollen Extracts

It is a chemical problem to determine the proper solutions for extracting the active and soluble principles of the pollen in order that their potency may be preserved over a long time. Weighed quantities of the dried pollen are macerated with measured quantities of the extracting menstruum and then, in Pyrex jars with agate marbles, are rotated for several days to assure the crushing of the pollen granules and the extraction of all of their soluble constituents. The extract is then filtered and is promptly sterilized by passing through Berkefeld germ-proof filters. This work of sterilization must be carried on in a bacteriological laboratory under the strictest bacteriological technic to avoid the subsequent contamination of the filtrate. This extract of the pollen principles is then subjected to bacteriological tests to assure its absolute sterility, and since the product is manu-

factured under a government license and under the direct supervision of the United States Public Health Service, the filled containers are likewise subjected to rigorous tests to demonstrate the fact that they are entirely free from germ life.

The Chemical Nature of Pollen Extracts

Quite naturally there has always been some conjecture as to what the real nature of the extracted portion of the pollen is. It has been concluded that the pollen extract was a solution of the proteins of the pollen, and such is a logical conclusion. There have been those who have at-

STERILIZING POLLEN EXTRACT BY BERKEFELD FILTRATION

tempted to standardize pollen extracts by the estimation of the nitrogen content by the Kjeldahl method. The work done in this laboratory indicates the fact that up to certain concentrations, practically all the nitrogen content of pollen extracts is in the form of protein nitrogen, and since the nitrogen of these extracts bears a definite relationship to the amount of pollen weighed out for the extracting process, the estimation of the nitrogen in the pollen extract has no more significance than the knowledge of the amount of pollen extracted.

From pollen extracts have been isolated at least four protein fractions, —proteose (*A* and *B*), albumin, and glutelin. Furthermore, when these

protein fractions are used for testing hay-fever patients, it is found that some patients react to one or more of these particular fractions and not to others. It is entirely possible that the further work with these different fractions may, in the future simplify and make more certain the desensitization of those individuals who have such marked symptoms when the pollens are in the air.

Testing and Desensitizing Hay-Fever Patients

Just why one per cent of the population of the United States as well as many individuals in other countries should show these distressing symp-

STERILITY TESTS ON POLLEN EXTRACTS ASSURE THE STERILITY OF EACH BATCH

toms from invisible pollen grains floating in the air, has never been satisfactorily explained. We say that they are sensitized to the pollen and their sensitization may be demonstrated by simply allowing the patient to inhale a tiny bit of the pollen from the end of a toothpick. The mere contact of a small amount of those pollens, to which they are sensitized, with the mucous membrane of the nose will suffice to bring on a violent attack of sneezing. In determining this sensitization, however, it is customary to make a tiny scarification upon the skin of the patient. Usually the arm is taken and to very slightly abraded areas the pollen extracts are applied in

a regular order. Hay-fever patients or those sensitized to different pollens show most pronounced skin reactions in the forms of great hives or wheals that appear at the point where the pollen extract is applied to the abraded

FILLING POLLEN EXTRACTS INTO VIALS—AN ASEPTIC PROCEDURE

skin, and which disappear after an hour or so. Through the aid of these skin tests, taken in conjunction with his knowledge of the pollens that are found in the air at the time when the patient experiences his symptoms, the

physician is able to demonstrate the particular pollen or pollens to which the patient reacts.

Using extracts of these same pollens, the physician is frequently able to desensitize his patient. By beginning several weeks before the time for the expected onset, giving first small and then gradually larger doses at regular intervals, he gradually accustoms his patient to the offending substance. If he carries his dosage sufficiently high, the patient will have acquired a tolerance and when the time comes that the patient begins to breathe air that is filled with the pollens to which he is susceptible, the amount of toxic substance which he absorbs will be small in comparison

MAKING THE SKIN TESTS ON THE ARM OF THE HAY-FEVER PATIENT TO FIND THE PARTICULAR POLLENS THAT CAUSE HIS SYMPTOMS

with that to which his system is accustomed, and the usual symptoms will probably be avoided.

Each year the physician interested in the study of hay-fever becomes more and more adept at this desensitization. More and more is he able to sense the individual's degree of sensitization, and more and more does he become able to prevent, by this preseasonal treatment, the annoying symptoms. Because each patient varies in his susceptibility, each hay-fever sufferer presents an individual problem, yet apparently the time is not far distant when, with careful study of the sensitization of his individual patients, the physician will be able to help him meet the accustomed hay-fever season without fear. With the newer method of finding the pollens to which the patient is sensitized, and with stable and potent pollen ex-

tracts available, the physician of today may build up the dosage to a complete desensitization of the patient. When desensitized, the patient may expect to continue his regular work and even his pastimes throughout the hay-fever season and without inconvenience.

COLUMBUS MEETING OF THE AMERICAN CHEMICAL SOCIETY PRELIMINARY ANNOUNCEMENT

The Spring meeting of the A. C. S. will be held in the new chemistry building at the Ohio State University, April 29th to May 4th, 1929. The program of the Division of Chemical Education will include a Symposium on Lecture Experimentation and two half-day sessions for the reading of miscellaneous papers.

The local department of chemistry has indicated its willingness to furnish space for appropriate exhibits during the meeting. Individuals, schools or firms wishing to take advantage of this opportunity should communicate at once with Dr. Jesse B. Day, Local Secretary, Division of Chemical Education, Ohio State University, Columbus, Ohio.

Those who contemplate presenting papers before the Division are requested to note that:

1. All papers presented at a meeting of the A. C. S. are the property of the Society unless released by the editors.
2. No paper should be presented which has been offered for publication elsewhere.
3. Papers must be submitted in full to the Secretary of the Division at least one month before the meeting. Papers received too late for inclusion in the Columbus program will be held over, with the author's consent, for the Minneapolis meeting in September.
4. Lantern, blackboard and lecture-table facilities will be available.
5. The time available for any paper will be necessarily limited.

R. A. BAKER, *Secretary*,
Division of Chemical Education

Use Aluminum Cans for Food Preservation. The up-to-date housewife has for some time appreciated the value of aluminum for the cooking and preparation of foods, and now the commercial canners are beginning to realize that aluminum may turn out to be the ideal material for the manufacture of containers for canned foodstuffs.

Dr. H. Serger, a German investigator, has already obtained encouraging results on this point. He has found that aluminum is much less attacked by fruit acids than is the tin of the usual tinned iron cans.—*Science Service*

LIQUID AMMONIA AS A SOLVENT AND THE AMMONIA SYSTEM OF COMPOUNDS. III. THE PROPERTIES OF SOLUTIONS OF METALS IN LIQUID AMMONIA

WARREN C. JOHNSON, UNIVERSITY OF CHICAGO, CHICAGO, ILLINOIS, AND W. CONARD FERNELIUS,* STANFORD UNIVERSITY, CALIFORNIA

In an earlier article of this series[1] the solvent properties of liquid ammonia were discussed in some detail. In particular it was pointed out that ammonia closely approaches water in its ability to dissolve salt-like substances, forming solutions capable of conducting the electric current. Ammonia differs from water, however, in that it dissolves several of the strongly electropositive metals without an appreciable reaction taking place between the metal and the solvent. Solutions of metals in a non-metallic solvent are little known to scientific workers and it is not unreasonable to suppose that a study of the properties of such solutions might yield many new and interesting facts, especially concerning that condition of matter commonly called "the metallic state."

The present article is an attempt to describe the more important results obtained from the study of solutions of metals in liquid ammonia. These results concern for the most part the work of Prof. Charles A. Kraus of Brown University and his students and relate not only to considerations of the metallic state but also to an interpretation of numerous chemical reactions.

Solubility of Metals in Liquid Ammonia

That the alkali metals are soluble in liquid ammonia was first observed by Weyl[2] in 1864. He brought together sodium and potassium with gaseous ammonia under pressure and obtained the characteristic blue-colored solutions. Later investigators, including Seely,[3] Moissan,[4] and Guntz,[5] added lithium, cesium, rubidium, calcium, barium, and strontium to the list of soluble metals. Cottrell[6] has found magnesium to be slightly soluble.

One is immediately impressed by the character of these solutions since they contain a metallic constituent dissolved in a non-metallic medium. Due to the numerous difficulties encountered in the manipulations for studying their properties, comparatively little has been known about

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[1] THIS JOURNAL, **5**, 664 (June, 1928).

[2] Weyl, *Ann. Physik*, **121**, 601 (1864).

[3] Seely, *Chem. News*, **23**, 169 (1871).

[4] Moissan, *Compt. rend.*, **136**, 1177 (1903); **127**, 685 (1898).

[5] Guntz, *Ibid.*, **133**, 874, 1209 (1901).

[6] Cottrell, *J. Phys. Chem.*, **18**, 85 (1914).

them until recent years. It is to Ruff and Geisel,[7] Gibson and Argo,[8] and especially to Kraus[9] that we owe our present knowledge concerning such solutions.

The high solubility of the alkali metals in liquid ammonia is remarkable. The data for lithium, sodium, and potassium are given in the following table.

TABLE I

SOLUBILITY OF METALS IN LIQUID AMMONIA AT —33°

Metal	Grams of metal dissolved by 100 g. NH_3	Atoms of metal dissolved by 1 mol NH_3
Lithium	11.3	0.28
Sodium	24.6	0.18
Potassium	49.0	0.21

It is seen that these solubilities are rather great when it is recalled that at 18°, 35.9 g. of sodium chloride or 11.1 g. of sodium sulfate dissolve in 100 g. of water.

Solubility measurements ranging from —100° to 20° have been determined for the alkali metals in ammonia. The change in the solubility with the temperature is scarcely appreciable. The solubility of potassium increases slightly with decreasing temperature, that of sodium increases with increasing temperature, while that of lithium appears to undergo no change throughout a considerable temperature range. Accordingly, we can conclude that the heat of solution of these metals in ammonia is comparatively small.

The process of solution of the alkali metals is interesting. When sodium is subjected to condensing ammonia, by cooling the vessel containing the metal which is connected to a source of liquid ammonia, before any ammonia is visibly condensed to the liquid state, it gradually loses its luster, assumes a dark hue, and increases in bulk. The solid then appears to become pasty, and finally we have only a homogeneous mobile liquid. During the liquefaction, and for a little time following, the mass is of a lustrous, copper-red hue; the condensation of the ammonia and its mingling with the liquid steadily goes on, the liquid is progressively diluted, and, passing through a variety of tints by reflected light, at last becomes plainly transparent and of a lively blue color by reflected as well as by transmitted light; the liquid now closely resembles a solution of aniline blue or other pure blue dyestuffs. On reversing the process by allowing the ammonia to escape slowly from the vessel, the ammonia gradually evaporates out of the liquid, and the changes observed during the condensation appear in the

[7] Ruff and Geisel, *Ber.*, **39,** 831 (1906).

[8] Gibson and Argo, *Phys. Rev.*, **7,** 33 (1916); *J. Am. Chem. Soc.*, **40,** 1327 (1918).

[9] (*a*) Kraus, *J. Am. Chem. Soc.*, **29,** 1557 (1907); (*b*) **30,** 653 (1908); (*c*) **30,** 1197 (1908); (*d*) **30,** 1323 (1908); (*e*) **36,** 846 (1914); (*f*) **43,** 749 (1921).

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reverse order, till at last the sodium is restored to its original bright metallic state. If the evaporation be conducted slowly and quietly the sodium is left in crystals of the form seen in snow. The formation of the transparent blue liquid and the restoration of the sodium are steadily progressive.[10]

The copper-red concentrated solutions possess metallic luster but appear blue in thin sheets by transmitted light. However, even for the blue rays of light, the absorption by these metallic solutions is very great. A solution of sodium in ammonia containing one two hundred fiftieth gram atom of metal per liter just allows the filament of a 16 candle-power lamp to be distinguished through a thickness of one centimeter. Perhaps the most interesting thing concerning these solutions is that the color and the light-absorbing power is the same for all the alkali metals.

Reaction of Ammonia with Dissolved Metals

One is at once impressed by the ability of this solvent to dissolve such strongly electropositive metals without appreciable reaction taking place between the metal and ammonia. In this respect ammonia differs from water in solvent properties. We know that an alkali metal reacts readily with water to give an aquo base and liberate hydrogen,

$$2Na + 2H_2O = 2NaOH + H_2$$

While this reaction is not appreciable in ammonia at low temperatures over a short period of time, it becomes noticeable on long standing or at more elevated temperatures. The reaction is strictly comparable to that between an alkali metal and water,

$$2Na + 2NH_3 = 2NaNH_2 + H_2$$

except that in place of the aquo base there is formed in the case of ammonia the ammono base, sodium amide.[11]

It is interesting to note that the reaction between the metals and ammonia is greatly influenced by catalysts. Whereas a solution of sodium in ammonia may be preserved for a couple of weeks, even at room temperatures, in the presence of iron oxide or finely divided platinum the sodium is completely converted to sodium amide within an hour. Practically all the metals, metallic oxides and hydroxides, and even solid sodium amide, serve to catalyze this reaction.

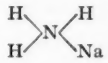
The Formation of Compounds between Metals and Ammonia

When these solutions of the alkali metals in liquid ammonia were first studied by Weyl in 1864, he was led by his observations and by the radical

[10] The above paragraph is taken with few modifications from the original paper of Seely. This early investigator is remarkable for his clear insight into the problem of metallic solutions and his adequate presentation of the subject.

[11] THIS JOURNAL, **5**, 828 (July, 1928).

theory, which dominated chemistry to a considerable degree at that time, to regard the solutions as substituted ammonium radicals, the metal taking the place of one of the hydrogen atoms of the ammonium group,



Later, Seely showed that true solutions result in the dissolving of the alkali metals by ammonia. From a consideration of the optical properties of these solutions, he concluded that a compound was not formed between

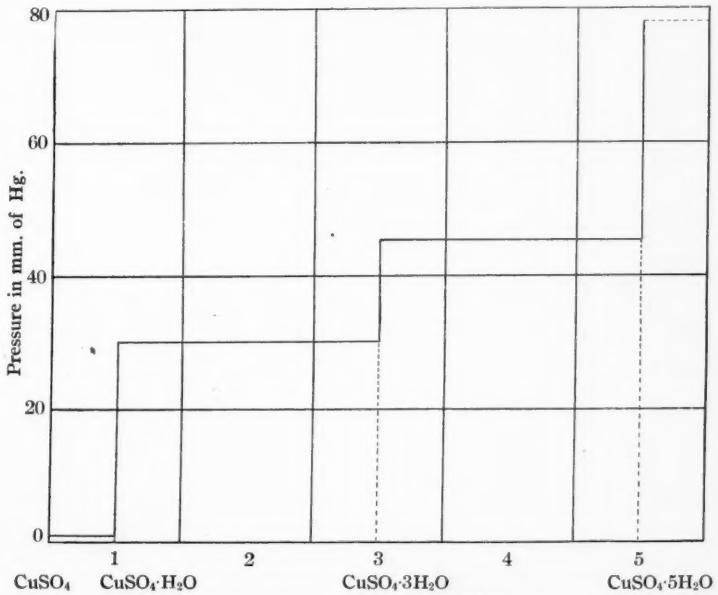


FIGURE 1.—SYSTEM COPPER SULFATE–WATER AT 50°

the two components. Neither Weyl nor Seely, however, was able to give quantitative data in support of his contention.

The subject of metallic solutions lay practically dormant until about 1890 when Joannis[12] undertook an extended series of investigations in this field. He was the first to bring quantitative data to bear on this problem by measuring the vapor pressure of solutions of sodium and potassium in ammonia and determining the composition of the solid phase separating from saturated solutions. He interpreted his results in accordance with Weyl's ideas and called the supposed combinations, $NaNH_3$ and KNH_3,

[12] Joannis, *Compt. rend.*, **112,** 391 (1891); **113,** 795 (1891); **115,** 820 (1892).

"metal ammoniums." Joannis' methods of investigation, depending as they did upon vapor-pressure measurements and optical observation, have since been shown to be untrustworthy. In his vapor-pressure determinations he measured nothing more than the pressure of a saturated solution of metal in ammonia and not that of a compound such as $NaNH_3$; while optical observations were of no value since these concentrated solutions exhibit metallic reflection and hence are opaque.

That Joannis did not measure the vapor pressure of "metal ammoniums" follows easily from a consideration of the phase rule. The equilibria

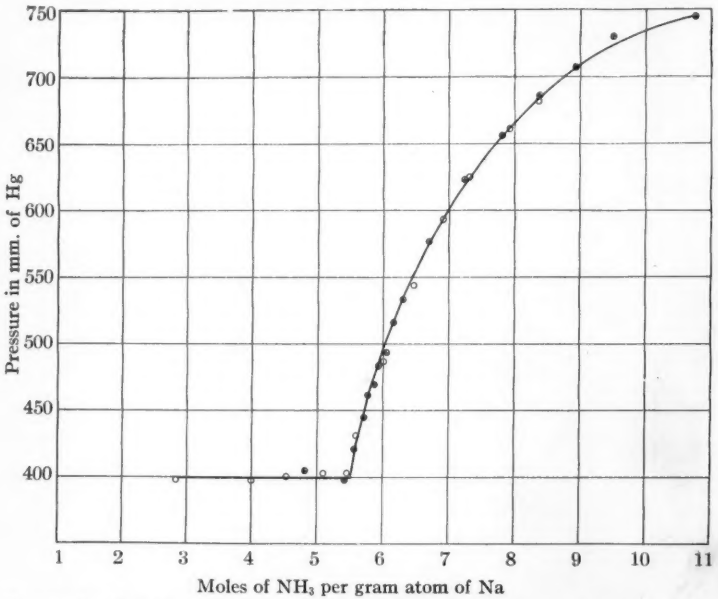


FIGURE 2.—THE VAPOR PRESSURE OF SOLUTIONS OF SODIUM IN LIQUID AMMONIA AT —33°

between the phases may be brought out more clearly by first considering a familiar system. Let us consider the vapor pressure of the system water and copper sulfate (a salt capable of combination with water to form definite hydrates). A dilute solution of copper sulfate in water has a vapor pressure less than that of pure water by an amount depending upon the concentration of the copper sulfate. Suppose now that water is being continuously evaporated, *e. g.*, removed with a vacuum pump. As the solvent is removed the vapor pressure is progressively lowered (Figure 1) until the solution becomes saturated and the compound, $CuSO_4 \cdot 5H_2O$, is

separated out. During the process of crystallization, the pressure remains constant but drops to a lower value as soon as all of the solvent water has been removed. The first constant value is that for the system

$$\text{Saturated solution} \rightleftharpoons CuSO_4 \cdot 5H_2O \text{ (solid)} + H_2O \text{ (vapor)}$$

while the second is that for the system

$$CuSO_4 \cdot 5H_2O \text{ (solid)} \rightleftharpoons CuSO_4 \cdot 3H_2O \text{ (solid)} + 2H_2O \text{ (vapor)}$$

Similarly, the other two horizontal parts of the curve are given by the systems,

$$CuSO_4 \cdot 3H_2O \rightleftharpoons CuSO_4 \cdot H_2O + 2H_2O$$

and

$$CuSO_4 \cdot H_2O \rightleftharpoons CuSO_4 + H_2O$$

This simple example illustrates both the behavior of a saturated solution and that of a hydrate (compound of solute and solvent).

A comparison of the above curve with that for a solution of sodium in ammonia (Figure 2) shows that the latter reaches a constant vapor pressure only at the concentrations involving an equilibrium between the saturated solution and vapor, consequently, no compound between the sodium and solvent is formed. Joannis argued, however, that the decomposition pressure of "sodium ammonium" is the same as the vapor pressure of its saturated solution. The phase rule tells us that such a condition could be realized only at one definite temperature, evidently that temperature at which Joannis has conducted his experiments. Measurements at other temperatures, however, give the same type of curve as Figure 2, showing that the solid phase initially separating from solution is identical with the solid phase (sodium metal).

The reason why Joannis was so thoroughly convinced of the existence of the "metal ammoniums" was because of his observation that the solid, which initially precipitates, appears to possess the same color of metallic reflection as does the solution itself, while, as is well known, the free metal possesses white metallic reflection. Ruff and Geisel claimed that this property was due to an adherent film of saturated solution and were able to actually press out this solution at low temperatures between linen in the case of lithium in contact with ammonia, and by carefully studying the vapor pressure of this system, Kraus showed that nothing other than a solution of lithium in ammonia was present. The surface forces of the alkali metals are very great and cause the metal to cling very tenaciously to its solution. For this reason, the analyses which Joannis made on the apparently solid phase mean nothing.

It is unfortunate that the term "metal ammonium" has crept into the chemical literature. Joannis was a very ardent worker and, aided by Moissan and others who adopted his technic and ideas, materially advanced our

knowledge of reactions in liquid ammonia. In fact, the influence of this school has been so widespread that today, twenty years after the death blow of the "metal ammonium" theory, the term is still used.[13] As Kraus and Ruff and Geisel, quite independently, have said, the term should be stricken from the literature.

The vapor-pressure curve for the system calcium–ammonia, however, presents quite a different situation (Figure 3). Here the definite compound, $Ca(NH_3)_6$, is obtained which Kraus[9b] has proposed to call calcium hexammonate. Mentrel[14] and Roederer[15] have prepared the analogous barium

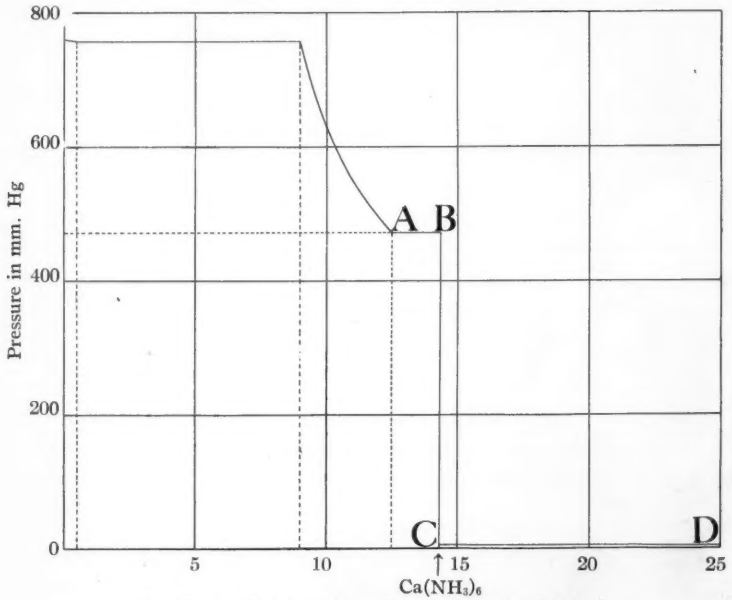


FIGURE 3.—THE SYSTEM CALCIUM–AMMONIA AT 32.5°

and strontium hexammonates. These compounds are to be regarded as ammonates similar to ammonated salts, such as $CaCl_2 \cdot 6NH_3$. There is no evidence for assuming that they are "metal ammoniums" in which the metal is joined to nitrogen in the ammonium radical.

It is interesting to note that the value of the heat of solution of the alkaline-earth metals in ammonia is considerably higher than that of the

[13] Guntz and Benoit, *Bull. soc. chem.* (4) **41,** 434 (1927).
[14] Mentrel, *Compt. rend.*, **135,** 790 (1902).
[15] Roederer, *Ibid.*, **140,** 1252 (1905).

alkali metals. This is an indication that there is a combination in the case of the alkaline-earth metals whose formation is accompanied by an energy change. Such an energy change is almost inappreciable when an alkali metal dissolves in ammonia.

The Conductivity of Solutions of Metals in Liquid Ammonia

The measurements of the conductivity of solutions of metals in liquid ammonia present the unusually interesting possibility of determining the nature of the conduction process in metals. Ordinary metallic conduction

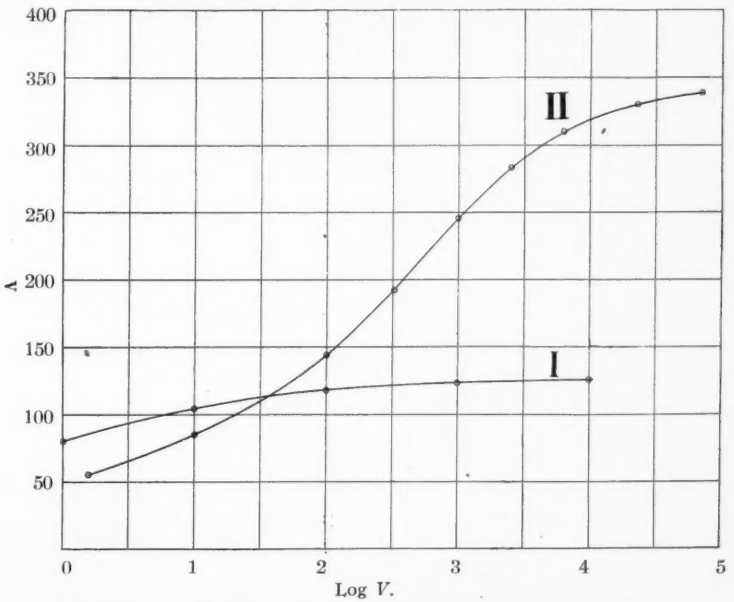


FIGURE 4.—(I) KNO_3 IN H_2O AT 18°: (II) KNO_3 IN NH_3 AT —33°

differs markedly from electrolytic conduction in that in the former there is no appreciable transfer of matter accompanying the passage of the electric current. Due to this lack of material transfer there has been no direct proof of the existence of charged carriers in metals even though the postulation of a discreet structure of electricity demands some such carrier, the electron. The situation in a *solution* of a metal in an inactive, non-conducting solvent, however, is somewhat different. Here the solvent would serve as a basis of reference with respect to which the state of the system might be determined. It might be expected that such solutions of metals would exhibit pronounced metallic properties when concentrated,

and that, as the concentration diminishes, these properties would suffer modification gradually approaching a limiting condition which is characteristic of ammonia solutions.

Before discussing the conductivity of solutions of the metals dissolved in liquid ammonia, it seems advisable to first consider the conductivity of a typical electrolyte in ammonia and also in water. Figure 4 shows the form of the conductance curve for a typical electrolyte, potassium nitrate, in water and in liquid ammonia where the equivalent conductance, Λ, has been plotted against the logarithm of the dilution, log V.[16] As is readily seen the conductivity begins at a small value and gradually rises to a limiting value where the ionization is complete.[17]

Cady[18] in 1897 found that for a concentrated solution of sodium in ammonia no appreciable transfer of matter accompanied the conduction process, even for large currents, while in dilute solutions the alkali metal appeared to increase in concentration around the cathode. Shortly afterward, Franklin and Kraus[19] confirmed the fact that ammonia solutions of the alkali metals conduct electricity without polarization at the electrodes and found that the conductivity changed but slightly over the range of concentration observed in their experiments. Since that time Kraus[9] has investigated in detail the conduction process for solutions of the alkali metals in liquid ammonia and has drawn several important conclusions from his results.

The conductance curves for solutions of the alkali metals as determined by Kraus are shown in Figure 5. The form of these curves differ vastly from that shown above for a typical electrolyte; however, on closer inspection, it is seen that the curves from point A to point B resemble markedly the curve for KNO_3 in liquid ammonia (Figure 4). The extremely high conductivity of concentrated solutions shows that these solutions offer very little resistance to the passage of the electric current. In the case of sodium solutions, at a dilution of 0.5, corresponding approximately to a concentration of twice normal, the value of the equivalent conductance is 82,490 Kohlrausch units. Measurements on a saturated solution of sodium in liquid ammonia show that the conductance is thirty times the value at a

[16] For an explanation of the difference in the conductivity of the same salt dissolved in these two solvents see THIS JOURNAL, **5**, 666 (June, 1928).

[17] Although according to our more recent theories we now consider the ionization of strong electrolytes in water to be complete, we are not permitted to make the assumption that the same phenomenon is true for salts dissolved in non-aqueous solvents, especially in the case of liquid ammonia. The data at our disposal for the conductivities of strong electrolytes dissolved in liquid ammonia indicate that at low concentrations the law of mass action is obeyed.

[18] Cady, *J. Phys. Chem.*, **1**, 707 (1897).

[19] Franklin and Kraus, *Am. Chem. J.*, **23**, 277 (1900).

dilution of 0.5.[20] In other words the conductance of a saturated solution is about one-half that of metallic mercury and of the same order of magnitude as that of such metals as strontium and iron. Such a high value must represent primarily metallic conduction. Now what theory of the conductivity of metallic solutions will account for the two types of conduction indicated by the conductance curve as well as for the observation that during electrolysis of these solutions there is an intensification of the blue color around the cathode and a corresponding fading out around the anode?

The explanation given by Kraus for the phenomena described above is

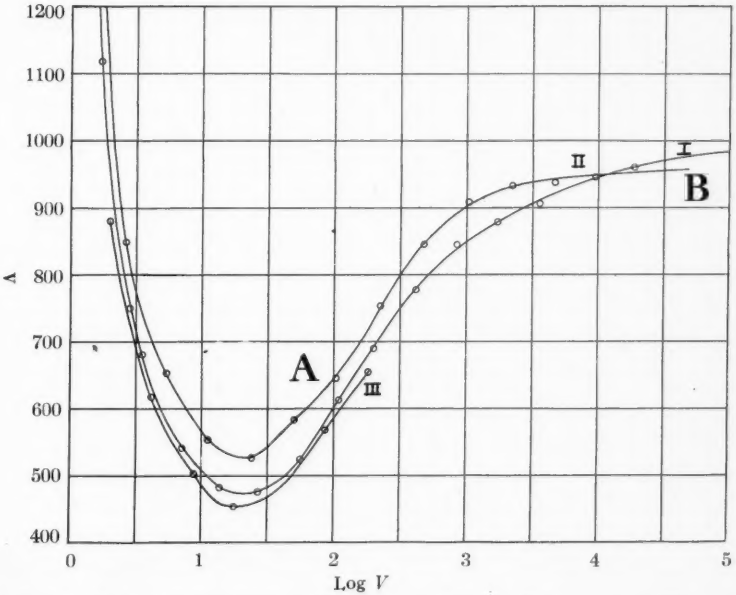


FIGURE 5.—THE CONDUCTIVITIES OF SOLUTIONS OF SODIUM (I), POTASSIUM (II), AND LITHIUM (III) IN LIQUID AMMONIA AT —33°

that there exists in such a solution an equilibrium of the unionized metallic atom with its positive ion and the negative electron,

$$Na \rightleftharpoons Na^+ + \epsilon^- \qquad (1)$$

The metal atom is to be regarded then as an electrolyte, similar to an ordinary salt, which in solution dissociates into its ionic constituents. Furthermore, the positive ion, Na^+, arising from such a dissociation is identical with the positive ion resulting from the dissociation of the metallic amide,

[20] Kraus and Lucasse, *J. Am. Chem. Soc.*, **43**, 2529 (1921).

$NaNH_2$, or any of the salts of that metal, NaCl, etc. In order that the electron may exist in solution and at the same time offer considerable resistance to the passage of the current, the electrons in dilute solutions must be considered to be associated with molecules of the solvent. Hence, there exists a second equilibrium between the negative carrier, the free electron, and ammonia,

$$\epsilon^-(NH_3)_n \rightleftharpoons \epsilon^- + nNH_3 \qquad (2)$$

where $\epsilon^-(NH_3)_n$ represents the solvated electron or negative carrier. The conductance of a system such as the following,

$$Na + nNH_3 \rightleftharpoons Na^+ + \epsilon^-(NH_3)_n \qquad (3)$$

would give a curve of the type shown between the points A and B (Figure 5) where the limiting value of the conductance is that value representing the dissociation of all the metal into its ionic constituents.

This explanation does not as yet, however, account for the very high conductivity of concentrated solutions of metals in liquid ammonia. In order for such a high conductance to exist, a large number of carriers must be present or the speed of the carriers must be very great. Actually both of these factors exert an influence and they may be accounted for if we assume that as the concentration of the metal in solution increases the carriers become detached from their associated ammonia molecules and thereafter migrate as free or relatively less solvated electrons; *i. e.*, there has been a shift in the second equilibrium toward the right. Such a condition fulfils the requirements for metallic conduction in which process one assumes the current to be carried by the electron moving with a high velocity. Now as the concentration is decreased the equivalent conductance decreases rapidly because the electrons become more and more solvated or a larger number become solvated; but as the solution is progressively diluted the electrolytic properties become more pronounced, causing the conductance to rise gradually to a limiting value after passing through a minimum.

A very striking fact is found when the conductances of the alkali metals—lithium, sodium, and potassium—in dilute solutions are compared. The values seem to differ only as regards the conductances of the positive ions. That is, at concentrations where the dissociation is high, the differences in the conductances of the three solutions at a given equivalent concentration may be accounted for by the differences in the mobilities of the positive ions. This fact implies then that the mobility of the negative carrier in all these solutions is the same and furthermore that the negative carriers must be identical in the different solutions. This fact gives further evidence that the negative carrier is identical with the electron. Another confirmation of this result is brought out when these solutions are examined photometrically. Gibson and Argo[8] have found the absorption spectra of liquid am-

monia solutions of lithium, sodium, potassium, magnesium, and probably also calcium at equivalent concentrations to be identical. Since the positive ions of all these solutions (Li^+, Mg^{++}, etc.) are colorless, Gibson and Argo's results indicate that the coloring principle, the solvated electron, in all these solutions is the same.

Kraus has admirably summed up the results of his studies of the conductivities of solutions of metals in liquid ammonia.[9f]

"These solutions, therefore, constitute a connecting link between metallic and electrolytic conductors. In dilute solutions the process is, at least in part, electrolytic. A portion of the current is carried by the positive carriers as they appear in solutions of the common salts. The negative carrier is chemically uncombined, but is associated with one or more molecules of the solvent. These carriers are identical for solutions of all metals, and, when the discharge occurs at the anode, the only material process which takes place is that a portion of the solvent is left behind in the immediate neighborhood of this electrode. As the concentration of the solution increases, the nature of the phenomenon changes only in so far as the combination of the negative carrier with ammonia is affected. At the higher concentrations, the negative carriers are free from association with the ammonia molecules to a greater and greater extent. And, since under these conditions the negative carrier is associated with no matter of atomic dimensions, it follows that all the material effects cease so far as these carriers are concerned. It is not to be understood that a given carrier is free from association with the solvent molecules for any considerable period of time. Obviously, an equilibrium must exist between the free carriers and the combined carriers and ammonia, which results in a constant interchange between the free and bound carriers. During the interval over which these carriers are free from the solvent molecules, they conduct just as they do in metals. As the concentration is further increased, the number of free carriers constantly increases. It is evident that their number in the more dilute solution, for example in the neighborhood of normal, must be relatively small, since at the higher concentrations the equivalent conductance reaches values some one hundred times as great as that at normal concentration. It is not possible to determine the actual number of carriers in the more concentrated solutions. In the more dilute solutions, however, it appears that the number of carriers decreases with increasing concentration, just as it does in the case of normal electrolytes in ammonia.

"There is nothing to distinguish the more concentrated solutions from actual metallic substances. It may be concluded, therefore, that the process of conduction in the case of ordinary metals is effected by means of the same negative carrier. Since this carrier is negatively charged and has sub-atomic dimensions, we may conclude that it is identical with the negative electron as it appears in radioactive and other phenomena."

The Density of Solutions of Sodium in Liquid Ammonia

When metallic sodium is added to liquid ammonia one of the first things that is noticed is the tremendous volume increase in the resulting solution. If a saturated solution is prepared, one in which for every atom of sodium (23 g.) there is present approximately 93 g. of liquid ammonia, the volume of the mixture is markedly higher than one would ordinarily predict. Twenty-three grams of sodium occupy about 23 cc. and 93 g. of liquid ammonia about 137 cc. at —33°. If no change in volume took place when

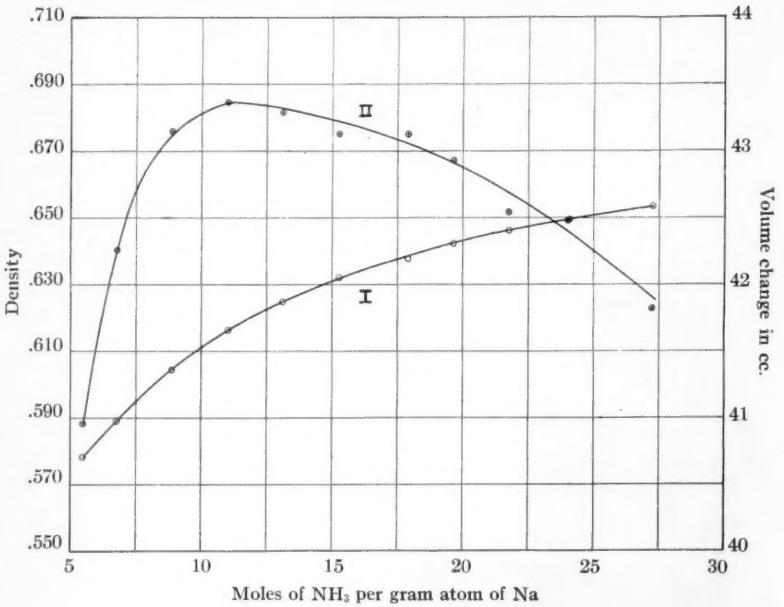


FIGURE 6

the sodium dissolves, the total volume of the solution would be about 160 cc. However, calculations from the measured density of the saturated solution show that the total volume is slightly more than 200 cc., which represents a volume increase of 41 cc. or approximately 25 per cent. One immediately asks, "Why should this solution exhibit such an abnormal volume increase?"

The only data available for the density of solutions of metals in liquid ammonia are those for sodium.[21] These measurements were carried out in such a way that the density was determined directly by means of a West-

[21] Kraus, Carney, and Johnson, *J. Am. Chem. Soc.*, **49**, 2206 (1927).

phal balance. The curves in Figure 6 show the values at —33° over a considerable range of concentration. The first curve shows the variation of the density with the concentration of the solution expressed in terms of the number of moles of ammonia per gram atom of sodium, while the second curve gives the volume change per gram atom of sodium.

A remarkable volume change is evident throughout the entire range of concentrations. A saturated solution has a much lower density than either of its two components; the density of the saturated solution is 0.5782 as against 0.6824 for pure ammonia and 0.9805 for sodium. As the concentration of the sodium in the solution decreases, the value of the density increases. In the dilute solutions, the value of the density approaches that of pure ammonia. The volume change, on the other hand, first increases with decreasing concentration, passes through a maximum value at a concentration of 11.25 moles of ammonia per gram atom of sodium, and then decreases in the more dilute solutions.

This striking property of these solutions may be explained by considering the condition of the sodium in solution. "If we bear in mind the fact that, in these solutions, sodium is present as a normal sodium ion, we must ascribe the volume change chiefly to the electron which, freed from the constraints under which it exists in the solid metal, occupies a relatively large volume in solution. In no other case heretofore investigated, either in process of solution or of compound formation, has a volume change of this magnitude been observed. It is known that the electron in liquid ammonia solution at higher concentrations is free to move as it is in metals. Since we have no adequate conception of the state of the electron in metals, we are unable to draw any definite conclusions regarding its state in liquid ammonia. However, it may be safely concluded that the electron is not combined with the sodium ion and that at low concentrations, at any rate, the electron is associated with ammonia molecules."[22]

Chemical Reactions of Solutions of Metals in Liquid Ammonia

Because of the salt-like nature of solutions of the strongly electropositive metals in liquid ammonia several types of reactions take place in ammonia which are entirely unknown in other solvents. The ionization of typical metals in liquid ammonia is practically the same as that of the corresponding salts in the same solvent and hence the equilibria involved are similar to those of salt solutions. Indeed, we not only have equilibria between different metals in ammonia solution but also equilibria between metals and typical salts in this solvent.[23] Solutions of metals in the presence of salts of other metals do not yield reaction products when these products are soluble, just as no metathesis in any solvent yields precipitates where all

[22] Ref. 21, p. 2213.

[23] Kraus, *J. Am. Chem. Soc.*, **44**, 1223 (1922) and other publications.

of the substances involved are soluble. When an insoluble product may be formed, however, this product is precipitated; thus the following reactions take place:

$$2KCl + Ca = \underline{CaCl_2} + 2K$$

$$AgI + Na = NaI + \underline{Ag}$$

and

$$BiCl_3 + 6Na = 3NaCl + \underline{Na_3Bi}$$

In the first case, the salt calcium chloride is insoluble and is precipitated; in the second, metallic silver is precipitated; and in the third, the precipitated metal itself is capable of forming anions, in which case a compound of the two metals, Na_3Bi,[24] is precipitated. Such metathetic reactions really involve an equilibrium between the different ions. Hence, the first equation above might be written,

$$\begin{array}{rcl} 2KCl & \rightleftharpoons & 2K^+ + 2Cl^- \\ & & + \quad\quad + \\ Ca & \rightleftharpoons & 2\epsilon^- + Ca^{++} \\ & & \downarrow\uparrow \quad\quad \downarrow \\ & & 2K + CaCl_2 \text{ (pptd.)} \end{array}$$

Numerous equilibria of the type,

$$Mg + 2KNH_2 \rightleftharpoons 2K + Mg(NH_2)_2,$$

are also known.[25] In all these reactions the metal behaves as though it were a typical electrolyte.

The use of the alkali and other metals for reductions is widespread but such usage is restricted to a considerable degree because of the lack of a suitable solvent for the metals. No such restriction exists with a liquid ammonia solution of the alkali metals. Consider the unusually favorable conditions for reaction between substances dissolved in ammonia and a solution of a metal in the same solvent. The factor of surface area is eliminated by making it infinite, causing reaction to take place readily and rapidly. The reducing properties of liquid ammonia solutions, especially as regards organic compounds, have been investigated to some extent. Outstanding among the investigators are Chaublay, Lebeau, Picon, and particularly Kraus, White, and co-workers.[26] The results of the experiments of the latter group of investigators indicate that it is the electron produced by the ionization of the metal in solution that is primarily responsible for the reduction reaction. Thus, for the reduction of phenyl chloride,

[24] Intermetallic compounds of this type will be discussed at some length in a later paper of this series.

[25] Bergstrom, *J. Am. Chem. Soc.*, **45**, 2788 (1923); **47**, 1836 (1925); **48**, 2848 (1926); **50**, 652 (1928).

[26] Kraus and White, *J. Am. Chem. Soc.*, **45**, 768 (1923); White, *Ibid.*, **45**, 779 (1923); White and Knight, *Ibid.*, **45**, 1780 (1923); Kraus and Kawamura, *Ibid.*, **45**, 2756 (1923); White and others, *Ibid.*, **46**, 961 (1924); Wooster, *Ibid.*, **50**, 1388 (1928).

$$6C_6H_5Cl + 6Na + NH_3 = 3C_6H_6 + (C_6H_5)_3N + 6NaCl$$

the following set of equations represent the steps of the reaction,

$$Na \rightleftharpoons Na^+ + \epsilon^-,$$

$$C_6H_5Cl + \epsilon^- \rightleftharpoons C_6H_5 + Cl^-,$$

$$6C_6H_5 + NH_3 \rightleftharpoons 3C_6H_6 + (C_6H_5)_3N$$

It is seen that the sodium delivers its charge to the chlorine atom with the formation of sodium chloride and that the organic reaction involved may be simply expressed as the interaction of the phenyl radical with the ammonia molecule. Numerous reactions of this type have been investigated but lack of space prevents their inclusion here.

In conclusion it might be recalled that the alkali metals dissolve in liquid ammonia with considerable increase in volume to form true metallic solutions having a characteristic blue color. Furthermore, these metallic solutions constitute a class of electrically conducting systems intermediate between metallic and electrolytic conductors. In dilute solutions, the metals are ionized into metal ions and solvated electrons. The metals in such solutions enter into typical metathetic reactions and bring about numerous reductions.

New Method Promises Check on Carbon Monoxide Poisoning. Carbon monoxide victims in closed garages, and suicides by the gas route, will in future become less numerous if the resuscitation method now being tried out by Dr. Ludwig Schmidt-Kehl of the University of Würtzburg works as well on human beings as it has on cats in the laboratory. Cats so far gone with carbon monoxide asphyxiation that they would surely have died have been "brought to" by placing them in a closed chamber of pure oxygen under pressure which was alternately decreased and increased in time with their own natural breathing rate.

Carbon monoxide poisoning, Dr. Schmidt-Kehl explains, is due to the abnormal appetite of the red blood corpuscles for the unwholesome gas. They take it up 250 times as readily as they do oxygen, which is the burden they normally carry to the body cells. The latter, deprived of their ration of oxygen, die of internal suffocation. With the red corpuscles out of commission, the situation might seem to be hopeless. But the German physiologist points out that the blood fluid itself, which ordinarily carries so little oxygen that it cuts no practical figure at all in respiration, may be induced to load up with an emergency ration by placing the asphyxiated animal or person in a closed chamber of oxygen under pressure.

If the pressure is kept at a uniform level it must be relatively high; but Dr. Schmidt-Kehl has found that much lower pressures can be used if these are alternately increased and lowered, in time with the breathing rate of the victim. This simulated breathing in a closed chamber, he has found, is much more likely to revive semi-asphyxiated animals than a uniform high pressure.

Thus far the work has been done only with a small experimental apparatus, with a chamber only large enough to contain a cat. Considerable difficulties have still to be overcome before the method can be adapted to clinical use for saving asphyxiated human beings.—*Science Service*

THE APPLICATION OF pH CONTROL

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Introduction

The theory of hydrogen-ion or pH measurements for the control of acidity and alkalinity has been known for a long time, but it is only within the past few years that this method has been applied to research and industrial work to any great degree. Some of the recent developments along this line will therefore probably be of interest.

The measurement of hydrogen-ion concentration differs from titration in that the latter determines total acidity or alkalinity, that is, both the ionized and unionized acid or alkali; while hydrogen-ion measurements determine the intensity of acidity or alkalinity, in other words, the actual concentration of H and OH ions in grams per liter. The hydrogen-ion concentration rather than the total acidity is of course the controlling factor in most chemical reactions.

Since the actual H-ion concentration of solutions, such as 0.0001, 0.0000001, 0.0000000001, etc., grams per liter, is very inconvenient and clumsy for use in actual practice, pH values, which were introduced by Sorensen, are almost universally used, the pH value of a solution being the logarithm of the reciprocal of the H-ion concentration in grams per liter.

$$\text{pH} = \log \frac{1}{H^+}$$

Thus the pH values of the above solutions are 4.0, 7.0, and 10.0, respectively.

The theory of pH control and the methods used have been given in a previous paper[1] and, therefore, will not be discussed here.

Water Purification

Coagulation to remove suspended matter, color, and bacteria is probably the most important step in the water-purification process. Coagulation is usually accomplished by adding aluminum sulfate to the raw water. The alum reacts with the natural alkali of the water, or alkalies which have been added, to form a "floc" of aluminum hydroxide or complex aluminum salts. This floc settles out and carries down the impurities with it.

Wide experience has shown that most efficient coagulation takes place at a definite pH value, this value being different for different waters. In fact the optimum pH for different waters in one state varies from 4.2 to 7.6. This is due to variations in color, turbidity, natural alkalinity,

[1] *Ind. Eng. Chem.*, **19**, 999–1004 (1927).

and a number of other factors. No definite optimum can therefore be given and it is essential that it be determined for each specific water. pH control is just as important if ferrous sulfate or sodium aluminate is used either in place of, or in conjunction with, alum. Accurate pH control results not only in savings in chemicals but also in producing a water of uniformly satisfactory quality.

Corrosion

The rôle that hydrogen-ion concentration plays in the corrosion of metals is well known. If, in the purification of a given water, the optimum pH for coagulation is 6.0, the resulting water will corrode the pipes of the distributing system. Lime or some other alkali must therefore be added to bring the pH value to 7.0 or above, to prevent corrosion and resulting red water. pH is also an important factor in the control of boiler feed water, cooling water for condensers, refrigerating brines, etc.

Probably the three outstanding factors in corrosion are pH, dissolved oxygen, and dissolved salts. Shipley and McHaffie have shown that corrosion of iron in the absence of oxygen is proportional to the hydrogen-ion concentration until pH 9.4 is reached, at which point hydrogen evolution and solution of iron practically cease. This pH corresponds to that produced by soluble ferrous hydroxide. When oxygen is present ferric hydroxide results, and the solution is thereby buffered at about pH 7.0, which condition tends to stimulate corrosion. The corrosive effect of oxygen is, however, diminished as the pH is increased. This shows the importance of pH control in the chemical treatment of boiler feed water.

In the case of refrigerating brines, the relative corrosion rate on iron and steel decreases with increase in pH, but above pH 12.0 pitting occurs. However, there is practically no pitting at about pH 10.0. With galvanized pipes, ice cans, etc., corrosion takes place in both acid and alkaline solutions, due to the amphoteric nature of zinc. To prevent corrosion of galvanized parts it is essential that the brine be kept only very slightly alkaline. The best practice is to keep the pH of the brine as close to 8.0 as is practicable. This does not sufficiently retard the corrosion of iron, so dichromate is usually added for this purpose. When the amounts of dichromate which are recommended by the Research Committee of the A. S. R. E. are used (100 pounds of sodium dichromate per 1000 cubic feet for calcium brines and 200 pounds per 1000 cubic feet for sodium and mixed brines), the brines are so colored that it is necessary to use a comparator in order to regulate the alkalinity.

When it is necessary to add caustic soda or lime to calcium and mixed brines to overcome acidity, the use of pH control is imperative. If a large excess of these alkalis are added to such brines, the density of the brines may be so greatly lowered, due to precipitation of salts, that the whole

system may freeze up. This can be prevented by adding only sufficient alkali to obtain the correct pH value.

Sewage and Industrial Waste Disposal

In the disposal of sewage the solids are first separated, principally by settling, and these solids are digested to destroy the organic matter. The work done at the N. J. Sewage Experiment Station has shown that the optimum reaction for digestion is between pH 7.3 and 7.6. If the sludge is either too acid or too alkaline, digestion is very slow, offensive odors are given off, and foaming occurs. This is true whether the digestion takes place in Imhoff, septic, or separate sludge digestion tanks.

The reaction of digesting material is closely connected with liquefaction and gasification of the material. At a pH of 7.3 liquefaction overbalances gasification. More gas is, however, formed as the pH is increased. This is of importance since the gas can be used for heating the sludge and heat also greatly increases the rate of digestion. By carefully controlling the reaction and heating the sludge to about 70°F., the time of digestion can be reduced from 8 to 12 months to 30 to 40 days.

During the past few years the disposal of industrial wastes, such as those from packing houses, tanneries, starch and sugar factories, canneries, textile mills, laundries, creameries, etc., has become of great importance. In the treatment of various textile wastes the most efficient purification takes place at pH values from 6.0 to 9.0, particularly if ferrous sulfate is used as the coagulant. The most general value is 8.0 to 8.2 for ferrous sulfate and 7.2 for alum. In the treatment of wastes from the syntheses of organic esters a pH of 8.0–8.2 was found best for removal of solids by continuous vacuum filtration. Vacuum and plate and frame filtration of wool washing liquors after coagulation failed until the pH value was adjusted to the proper point, in the neighborhood of 7.2, but was then readily carried out.

Paper Manufacture

The point in the paper-making process at which control of acidity is probably of greatest importance is in the precipitation of the sizing. The sizing agent, which is usually rosin soap, prepared from rosin and soda ash, is precipitated by means of alum. If too little alum is used, the size will not be completely and efficiently precipitated. On the other hand, additional alum over that necessary for proper precipitation not only adds to the cost of manufacture but also has a harmful effect, in that it tends to cause corrosion of the equipment and lower the quality of the paper. Various mills maintain pH values ranging from 4.2 to 7.0 but this is a factor which must be determined for each individual mill, as conditions vary considerably and the optimum pH value is affected

by a number of factors, such as hardness of water, degree of sizing desired, etc.

pH control is also of importance in the recovery of valuable materials from the white water, which is the water which comes from the paper machine. Where coagulation is used the pH value maintained by most mills is between 4.0 and 5.0. Here, too, the optimum may vary. Campbell showed that the sticking of pitch to the wire, press rolls, and felts could be prevented by adding alum until a pH of 4.3 was obtained. Roschier showed that the retention of fillers increases rapidly from pH 4.0 to 5.6, but remains constant between 5.6 and 7.0.

In the manufacture of satin white and blanc fixe proper pH control is unquestionably the most important factor. Blanc fixe has long been regarded by many as superior to satin white, as far as covering capacity and cost are concerned, but heretofore difficulty has been encountered in securing a material with the necessary fineness and smoothness. Accurate control of pH has overcome this difficulty.

Dyes and Pigments

In the manufacture of dyes it is well known that various batches usually vary in shade and that it is necessary to mix different lots to obtain the shade which has been adopted as the standard. Actual experience of many manufacturers has shown that not only can the shade be checked in different batches, but that the yields can also in many cases be materially increased by the application of hydrogen-ion control.

The same is true of pigments. For example, it is very difficult to produce successive batches of para red which have the same shade. This is now being accomplished on a large scale by the use of pH control. The quality of lithopone is dependent to a very large degree on the pH value maintained during its formation. While no definite value can be given to cover all requirements, in general, a pH in the neighborhood of 7.0 is probably the most satisfactory. In any case, after the proper pH value is obtained a product of uniform quality can be produced by always maintaining this value.

pH control is of equally great value in the dyeing of all kinds of fiber. Not only the amount of dye deposited on the fiber but, in many cases, the shades obtained are dependent on the pH of the dye bath. This is undoubtedly one important reason why dyers have difficulty in matching shades.

General Chemicals

In the manufacture of such materials as sodium carbonate and bicarbonate, primary and secondary sodium phosphates, aluminum sulfate, etc., pH control has proved to be a valuable tool. For example, in making

phosphates by the action of sodium hydroxide on phosphoric acid, the pH value of the mixture increases slowly until the first hydrogen is neutralized. The addition of a very small additional amount of caustic raises the pH at least one whole unit, for example, from 4.0 to 5.0. At this point the mixture contains only primary sodium phosphate. If, after this point is reached, additional sodium hydroxide is added the pH again increases slowly until the second hydrogen is neutralized. Again the addition of a very small amount of caustic causes the pH to rise suddenly from about pH 8.0 to 9.0. This means that the solution now contains only secondary sodium phosphate. By determining these break points and always maintaining these values, uniform products of high quality are obtained.

A similar method of control can be used in the manufacture of calcium phosphate where phosphate rock is digested with hydrochloric acid, and the resulting solution treated with lime. The monocalcium salt is formed at a pH of about 4.0, while the tricalcium salt results at about 8.5. Dicalcium phosphate is formed in slightly acid solution, but is unstable, apparently breaking down in time to form a mixture of the mono- and tricalcium salts.

In the manufacture of many salts, purification and crystallization may be materially affected by the pH of the liquors.

Chemical Analysis

It is common practice in soil and fertilizer analyses to determine the available phosphates by the use of a neutral solution of ammonium citrate. It is extremely difficult to prepare an exactly neutral solution by titration, but this can be done with the greatest ease by pH measurement.

In the separation of the copper and arsenic groups from the aluminum and zinc groups, the pH of the solution should be adjusted to 0.4–0.6 by means of acid cresol red. Fales found the optimum range for the quantitative precipitation of zinc as the sulfide to be 2.0 to 3.0. Below pH 2.0 completeness of precipitation falls off rapidly, while at pH 4.0 or above, although quantitative precipitation occurs, the precipitate is too slimy to filter efficiently. In addition, cobalt, nickel, iron, and manganese will also be precipitated unless the pH is maintained near 2.0.

In the precipitation of nickel as the diacetyl dioxime salt, if the cupric ion is present the pH of the solution must not exceed 5.0 or the cupric salt will come down, although ordinarily cupric diacetyl dioxime is fairly soluble. Aluminum hydroxide comes down most completely between pH 6.0 and 7.0.

The presence of potassium bitartrate in potassium antimonyl tartrate can be shown by a pH determination. A solution (1 to 20) of a pure

preparation has a pH of 4.1, but 1% of bitartrate lowers the pH to 3.4. If the minimum pH is therefore set at 4.0, the presence of more than 0.3% potassium bitartrate is excluded.

As shown by Kolthoff, similar tests can be used for detecting free sulfuric acid in various sulfates. It is essential that zinc sulfate be free from traces of acid when the salt is used in eye treatment. Kolthoff states that if a 1 to 10 solution has a pH of 4.6, it will contain less than 1 part of sulfuric acid in 200,000. If a 1 to 10 solution of copper sulfate has a pH of not less than 4.0, the presence of 1 part of free sulfuric acid in 2000 is ruled out. When a 1 to 20 solution of aluminum sulfate has a pH of 3.2, the presence of more than 1 part of sulfuric acid in 1000 is excluded.

Electroplating and Electrotyping

The importance of pH control is apparent from the fact that research at the Bureau of Standards and actual experience in many plants have shown that a large proportion of the troubles in nickel electroplating and electrotyping, such as pitting, cracking, curling, too hard or too soft a deposit, burnt deposits, etc., are due to improper acidity of the bath. Even slight changes in the acidity may cause marked effects upon the appearance or properties of the deposited nickel.

Using the colorimetric method, nickel electroplating and electrotyping solutions are generally maintained between pH 5.2 and 6.8. For plating under usual conditions in still tanks, the best pH is generally from 5.6 to 5.8. With a higher pH the deposits are softer and may be dull or burnt. With a lower pH the deposits are harder and brighter but more brittle.

In barrel plating, where the current density is low, a higher pH (6.0 to 6.2) is desirable. In solutions with a high nickel content, such as are now used in mechanical platers at a relatively high temperature and high current density, a lower pH (5.2–5.4) is often employed.

For nickel electrotyping on wax molds, a pH of 6.4 to 6.8 is usually employed. Where solutions are used exclusively for lead molds, a lower pH (6.0 to 6.4) is satisfactory. In any case, if a softer deposit is desired, the pH of the solution should be somewhat increased.

The acid zinc bath can be controlled in the same manner except that the pH should be maintained between pH 3.5 and 4.5.

Fermentation

Bacterial enzymes elaborated during growth determine the type of products from fermentations. Often, by suitable control of the pH of a fermentation mash, not only are alien organisms restrained but maximum activity of the desired enzyme is favored. This means a decrease in the time of normal fermentation. This principle finds wide application in

the production of solvents, manufacture of beer, wine, vinegar and cheese, in the digestion of sewage sludge, etc.

In the fermentation of molasses to ethyl alcohol it has been found that the alcohol has no appreciable effect on the pH and, due to the presence of buffers, there is very little change in the pH during the course of fermentation. The optimum pH for a given yeast is unaffected by varying the concentration of the wort, but varies with the strain of yeast. Different plants hold to slightly different values, but most molasses mashes are adjusted to between pH 5.0 and 6.0, the probable average being 5.4–5.6.

Fruit Jellies

The regulation of the pH of fruit juice, previous to the addition of sugar, results in larger yields and fewer failures in fruit jelly manufacture, and makes possible the production of jellies of optimum texture and stability. The researches of the Delaware Agricultural Experiment Station have shown that the total titratable acidity of fruit juices may vary over a wide range, yet jelly formation occurs only between fairly definite pH values. Above a pH of approximately 3.55 jelly formation does not occur. As the pH of the juice decreases from 3.55 to approximately 3.0, the strength of the jelly increases. At pH values below 3.0 the jelly becomes weaker and syneresis usually occurs. Several large fruit jelly manufacturers have reported that since they have taken the pH of the juice into consideration they have not had a single jelly failure.

Canning of Food Products

Full use can be made of the knowledge of heat penetration in canned foods only when we know the time necessary to destroy the bacteria which cause spoilage. While other factors, such as subdivision of material, method of processing, etc., influence heat penetration, it is certainly true that both the time and temperature necessary to effect sterilization depends to a large degree on the pH of the food.

In general, the lower the pH value the lighter the process required for sterilization. All the common fruits have a pH value below 4.0 and processing is relatively light. Tomatoes have a pH of about 4.2, closely approaching the fruits. Between 5.0 and 6.0 come most of the common vegetables, such as carrots, cabbage, beets, beans, asparagus, etc., and the process is heavier than for fruits. Above 6.0 come succotash, peas, corn, hominy, fish and meat, all of which require a very heavy process.

Gardening and Farming

Many who have tried to transplant laurel, rhododendrons, azaleas, ladyslipper, and many other wild flowers from their natural habitat to their own gardens, have wondered why these plants either died or

failed to thrive properly. This is usually due to the fact that they require a rather strongly acid or sour soil, while the soil of the average garden is alkaline or sweet.

Other plants, such as the rose, aster, crocus, etc., require a practically neutral soil and will not thrive in either a highly acid or a highly alkaline soil. It is therefore apparent that each plant has its own soil preference and, unless the pH of the soil is suited to the plants which it is desired to grow, the reaction must be changed to obtain the best results. The pH values required by most of the common flowers, shrubs, trees, and crops are now available and much greater success would be met with if growers would pay closer attention to this factor.

Ammonium Sulfate: Modified French Method of Production. According to the *Chemiker-Zeitung*, the erection of factories in France for the production of ammonium sulfate and cement by the Leverkusen process has been held up, as it is thought possible to convert gypsum into ammonium sulfate as in the method of the Badische company, together with the simultaneous production of cement. M. Baud, the discoverer of the new method, carries out the reaction between gypsum and ammonia under a pressure of about one atmosphere in the presence of carbon dioxide and loam, which, by reaction with calcium carbonate, gives a sludge. This, after complete washing out of the ammonium sulfate, is heated to 1500°C. whereby cement clinker of normal composition is formed. The solution contains 27–28 per cent. of ammonium sulfate. The German account states that a conflict is at present in progress between the producers of ammonium sulfate (who regard this as the best nitrogenous fertilizer) and the producers of calcium nitrate, who oxidize synthetic ammonia by the Bamag-Parsons method.—*Chem. Age*, **19**, 282 (Sept. 29, 1928).

Atmospheric Effects on Textiles. The influence exerted by excessively dry household atmosphere on the color and texture of rugs and other textile materials commonly used in homes will be the subject of study by the Holland (U. S. A.) Institute of Thermology, according to an announcement from the Holland Furnace Co., of Holland, Mich. The Institute of Thermology was established only recently. One of its chief objects is to make homes healthier places to live in and to improve the relative humidity in them so that fabrics, furniture, and other goods are not adversely affected. A prominent research engineer will be appointed to direct the investigations and tests, and the results will be placed before the public from time to time in the form of reports of findings. The science of domestic heating and ventilation will constitute the principal field of investigation.—*Chem. Age, Dyestuffs Mo. Suppl.*, **19**, 26 (Oct. 13, 1928).

Reduction of Magnetite by Iron Sulfide. An investigation of the rate of reduction of magnetite by ferrous sulfide has been completed by the United States Bureau of Mines. The results show that pure magnetite is reduced to some extent by ferrous sulfide at temperatures as low as 1000°C. and that the reduction may become almost complete in two hours' time at 1300°C. if there is a considerable excess of sulfide and if sulfur dioxide, sulfur trioxide, and elemental sulfur reaction products are removed as fast as formed. When these products are allowed to accumulate, the rate of reduction is lowered.—*Chem. Age*, **19**, 375 (Oct. 20, 1928).

THE PROCESSES OF COLOR PHOTOGRAPHY. III COLOR CINEMATOGRAPHY

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The various processes of color photography which have been described are applicable to motion picture work, though, owing to the long exposures required and the loss of light by absorption, no practical process utilizing the principle of the screen plate has as yet been developed for cinematography. A process of very similar type has, however, recently been introduced for amateur cinematography and will be described in the fourth of these articles. The motion picture processes, like other

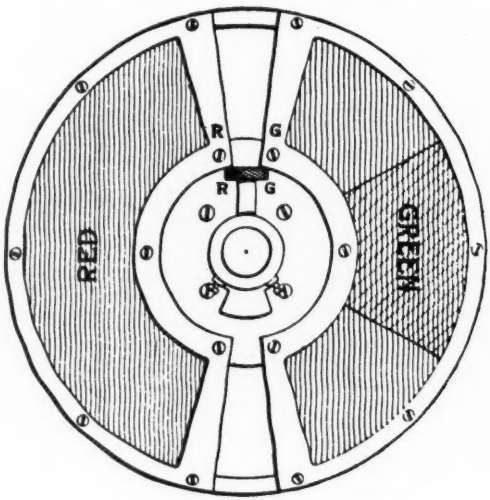

FIGURE 17.—Color Filter Rotating Disk for Kinemacolor Camera.

processes of color photography, are divided clearly into *additive* and *subtractive* processes, and, as in the case of the photography of stationary objects, the additive processes developed first.

Two-Color Processes

One possible simplification in color photography is the substitution of two colors for three. While with the three-color process we cannot expect to get results from the subtractive method equal to those given by the additive, in a two-color process the possibility of getting a satisfactory result with the subtractive method is somewhat greater than with an additive method. In order to get the whites and blacks with the

additive two-color process, it is essential that our two colors should be exactly balanced or *complementary*, as it is called, because otherwise they would not give white on the screen; and this condition that the two colors should be complementary to each other greatly limits the range of colors which can be obtained. When working the subtractive process, on the other hand, whites are obtained by the absence of any color at all, and blacks by both colors in full strength, so that colors can be used which are not exactly complementary to each other, and the range of possible colors which can be obtained is greatly extended.

Additive Processes

In the case of motion pictures, there are two methods of additive synthesis. Either the three pictures may be projected successively, persistence of vision being relied upon for the blending of colors, or the color units may be projected simultaneously, as is done in the triple projection lantern.

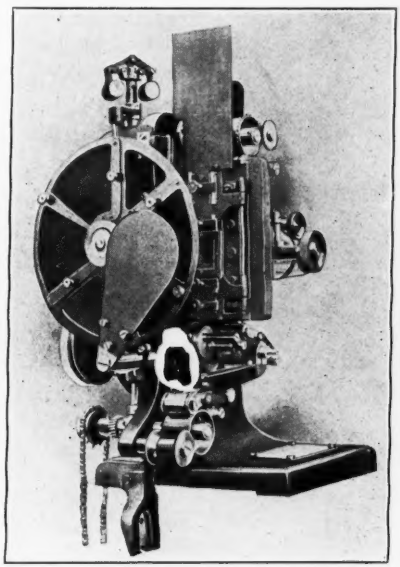

FIGURE 18.—Kinemaco or Projecting Machine.

Successive Projection.—The earliest practical cinematographic color process was a two-color process utilizing persistence of vision for the addition of the pictures. By means of a rotating disk (Figure 17) of color filters placed in front of the camera, pictures are taken on panchromatic film alternately through a red and a green filter, the pictures being taken at twice the normal speed, so that for each complete picture two negatives are made, one through each filter. The positives from these negatives are so projected through a machine similarly equipped with a rotating shutter, which is made to operate synchronously with the picture, that the pictures taken through the red filter are again projected through a red filter, and the green pictures similarly through a green filter (Figure 18). The succession of red and green pictures upon the screen produces complete synthesis by persistence of vision and gives the effect of a two-color additive picture.

This process was known as the *Kinemacolor* process and enjoyed a considerable success. It has often been revived with various modifica-

tions, such as coloring the successive frames on the film instead of using rotating filters or modifying the colors of the filters in the hope of improving the color rendering.

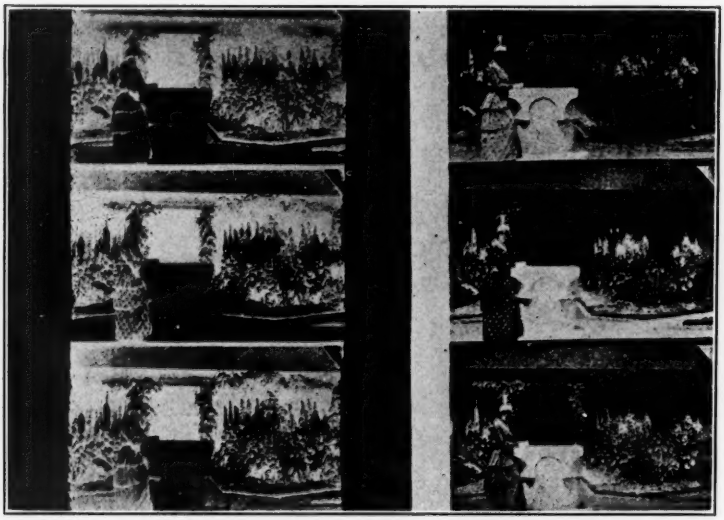

FIGURE 19.—Set of Gaumont Negatives and Positives.

Simultaneous Projection.—The most complete and satisfactory process of color cinematography is undoubtedly the simultaneous three-color additive process worked out in its complete form by Gaumont. Three lenses are used in the camera, and three pictures are taken through the primary color filters upon the same strip of film. A normal motion picture is 1 inch wide by $^3/_4$ inch high and corresponds to four sprocket holes in the film. The Gaumont pictures are three sprocket holes in height instead of four for each color, so that the whole set of color pictures corresponds to nine sprocket holes, and the film is two and

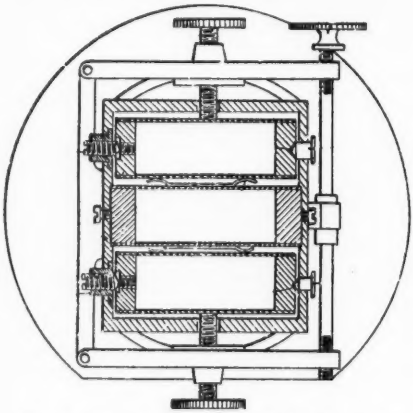

FIGURE 20.—Diagram of Three Lenses in Gaumont Camera.

a quarter times the length of the standard film (Figure 19). After each exposure the film is pulled down, therefore, the length of nine sprocket holes at one time, and a new set of pictures is taken, sixteen pictures a second being exposed just as normal pictures. The positives are projected in a machine fitted with a corresponding pull-down and gate and with three condensers and three sets of objectives fitted with special registering devices (Figure 20). The results given by this process are admirable, all colors being perfectly rendered and the quality being in every way first class.

Subtractive Processes

An advantage of the subtractive color process for motion pictures is that the film so produced can be shown in any ordinary machine, and this advantage is even greater in the case of motion pictures than in the case of ordinary lantern slides. The obvious method of making subtractive

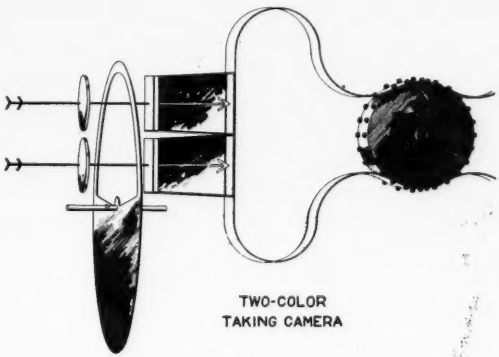

FIGURE 21

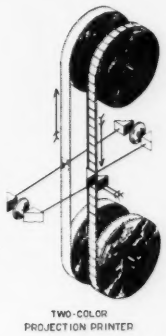

FIGURE 22

motion pictures would be to make three negatives and to superpose the negatives in printing, recoating the film each time, and using a dyed bichromate process or a process in which the silver image is made to mordant the dye and so is transformed into a color image. The recoating and re-registering, however, present very great difficulties in practice and make the process costly; and it appears likely that the subtractive processes of color cinematography will use only two prints, that is to say, they will be chiefly two-color processes and these two prints may be either in the one emulsion layer or in two emulsion layers on opposite sides of double-coated film, a method which appears at the present time to offer considerable advantages in the direction of simplicity.

It is clear that, since there are two sides to film, it is possible to coat an emulsion on each side of the film and to print the red image on one side and the green on the other. This process has been worked out in several

ways to a practical end, some of the color images being produced by the mordanting of a dye upon an image obtained by the conversion of the silver into some suitable substance, others by the imbibition of a dye into the gelatin, and still others by toning to colored images by chemical means.

A typical two-color subtractive process is that worked out by J. G. Capstaff in the Research Laboratories of the Eastman Kodak Company. The silver is treated in such a way that the reaction products harden the gelatin selectively and thus a silver negative is transformed directly into a dye positive. In order to apply this to motion picture work, the negatives are taken in a camera in such a way that red and green pictures are taken successively, one below the other (Figure 21). From this strip of negative film a master positive is made, and this is then printed by means of a special projection printer upon opposite sides of double-coated film (Figure 22). In this projection printer, the red positive is projected on to one side of the film and simultaneously the green picture on to the other, the images being slightly displaced vertically, so that they exactly register one on top of the other on opposite sides of the film. The emulsions being exactly the same and the light intensities the same, there is no difficulty in obtaining equal results in the two pictures. The strip is then developed and fixed for the two pictures and without further delay is passed into the bleach bath, which bleaches the silver and locally hardens the gelatin where the silver was present. The silver is then fixed out, leaving a clear-coated gelatin strip of film bearing, on both sides, the images in the form of hardened gelatin. The two sides are then dyed by passing through a dyeing machine, the side containing the pictures taken through the red filter being dyed blue-green, and the side containing the pictures taken through the green filter, red. On viewing the film so prepared, a two-color subtractive picture is seen, which, being on standard film, can be run in any machine in the same way as black and white.

A number of other workers in color photography have used similar processes; notably, Hernandez Mejia and Thornton, whose patents for film having images on opposite sides are of considerable value in this connection.

The Technicolor process resulted in a film having images on both sides, but the two images were printed separately and then cemented together back to back to make a compound film.

A very promising method of making subtractive pictures is the *imbibition* process. In this, dyed images are prepared upon master films, and the dyes are transferred in succession in register on to a single film coated with gelatin. Provided that the mechanical difficulties can be overcome and sharp pictures obtained, results should be excellent, and the process

has the advantage of giving a film which has exactly the same properties in regard to curl, etc., as the ordinary black and white film, so that it can be inserted with black and white film and does not involve any changes in projection. Theoretically, the imbibition process could be used for three-color as well as two-color pictures, although the difficulties increase rapidly as the number of transfers become greater.

Combinations of imbibition with other methods of making dyed images are very common in motion picture color processes.

Working Details for the Processes of Color Cinematography

Taking the Negative.—There are three general methods of arranging a camera for color photography:

In the first, which was that originally used in Kinemacolor, the pictures were taken serially, a rotating filter being used in front of the lens, so that the pictures were taken alternately through a red and a green filter (see Figure 17). The objection to this is that a quickly moving object is in a different position when the red negative is taken from that which it occupied when the green negative was taken; and there will therefore be shown on the screen alternate bands of red and green, which produce a colored striping at the edges of quickly moving objects. There is also the disadvantage that the exposure must necessarily be shorter because the two pictures must be taken in the same period as that in which one picture is normally taken. Sometimes an attempt is made to lessen this disadvantage by using very light filters. Such filters cannot be recommended, as they are invariably detrimental to the color rendering.

Another method of working is to take the two pictures, or in the Gaumont process, the three pictures, simultaneously, using two or three lenses (see Figure 21). In this case, the red picture being taken from a slightly different standpoint from that of the green picture, it will be impossible to register both the distance and the near foreground simultaneously. This defect may be called *stereoparallax*. It is partly in order to diminish this that especially narrow pictures are used in the Gaumont process, so that the taking lenses can be placed nearer together. Stereoparallax is a disadvantage only when dealing with really near objects. For any objects beyond twenty-five feet, it is negligible. The use of two lenses is advantageous as regards the exposure necessary, because the pictures are then taken at normal speed. The filters can be as light as is compatible with color rendering, and the whole aperture of the lens can be utilized.

Both the striping difficulty and stereoparallax can be avoided by using one lens for taking the two pictures, the light from the lens being split into several parts by means of prism systems. This is entirely satisfactory except for the loss of light involved. In practice, it is convenient for

distant scenes to have cameras using two lenses fitted with so-called *beam splitters* for near objects, where the stereoparallax would be fatal, while the method of successive pictures is now used chiefly in title cameras photographing still objects.

Production of the Positive.—The practical making of the positives for projection in the additive processes presents little more difficulty than for black and white work. More attention to detail is required, and a rather higher standard of regularity of quality must be maintained, but the process does not involve any special difficulty. When we turn to the subtractive processes, the positive making is, of course, the key to the whole matter. From every other point of view, these processes are the most satisfactory, and the only thing that has kept them back is the intrinsic difficulty of making the positives. A detailed discussion of the difficulties of the subtractive processes and of the methods by which they are overcome would occupy too much space here.

Projection.—The additive processes require, of course, their own special projector, the Kinemacolor machine having rotary filters which can be thrown out of the way, thus converting the machine to a black and white projector; while the Gaumont process requires a triple projection machine with registering arrangement which cannot easily be converted into a black and white projection machine. These special projecting machines are the great disadvantage of the additive processes and will probably always restrict their use.

Both the Gaumont and the Kinemacolor processes involve a considerable loss of light, so that more current has to be used in projection. The absorption of the Kinemacolor filters, which are as light as possible, is such that only two-thirds of the incident light reaches the screen, and for equal brightnesses two and a half times as much current must be used. With the Gaumont process, the matter is somewhat worse; the filters are not only slightly darker than the Kinemacolor filters, but the blue filter represents a loss of one-third of the light; since, while the blue contributes to the color of the scene, it adds very little indeed to the total brightness.

The subtractive processes, having their high lights represented by clear film, do not require any increase of current whatever, the brightness being the same as for black and white. This is one of the great advantages of the subtractive processes.

Among all processes of color photography, the rendering given by the three-color additive process is supreme. Indeed, under favorable circumstances, the color rendering by this process is almost perfect. The subtractive processes, even the best three-color processes, do not give such good results in regard to rendering as the additive processes, because no dyes can fulfil the theoretical conditions so correctly as can the projection filters.

As has been explained previously, when we turn to the two-color processes the position of the additive and subtractive processes in regard to color rendering is reversed, and the color rendering obtainable by means of the two-color subtractive process is intermediate between that of a three-color process and that of a two-color additive process.

From this general discussion of the processes of color cinematography, it will be seen that the additive processes, and especially the three-color additive process, while able to give photographic quality and color rendering superior to the subtractive processes, seem to have a somewhat limited field, owing to the necessity for the use of a special projecting machine. These are likely to survive for the very best three-color work.

For the wide field of general motion picture work, it is probable that a two-color subtractive process having the color in the film, so that it can be used in any projector without increase of light, must prove the most suitable, and that this process will be one having the two colors on opposite sides of double-coated film.

Succinchlorimide as New Water Purifier. The new water purifier that will not deteriorate with age, announced at the recent meeting of the American Chemical Society Institute, is still only in the initial stage of development, Major C. B. Wood of the U. S. Army Medical School emphasizes. While succinchlorimide, the new substance he has discovered, will purify water and has the great added advantage over other water purifiers of keeping indefinitely, its practical application is still a long way off.

Problems of large-scale manufacture and cost must be solved before it can be put into use by the army, and use by the general public for camping and vacations must wait until after it has been made available for the army, Major Wood said. The new substance is designed for use by men away from camp and good supplies of water. A small amount of the succinchlorimide will purify the water in a canteen and does not give any objectionable taste to the water.—*Science Service*

American Surgeons Celebrate Ether Day. A feature of the clinical congress of the American College of Surgeons, recently held in Boston, was the celebration of Ether Day in the Dome Room of the Massachusetts General Hospital, the building in which ether was given for the first time as an anesthetic during an operation on Oct. 16, 1846. A bronze bust of Dr. William T. A. Morton, the man who is generally credited with being the discoverer of ether as an anesthetic and who performed this first operation under ether 82 years ago, was presented to the hospital.

A number of distinguished foreign surgeons were guests of the College, among them Prof. Vittorio Putti of Bologna, Italy, who delivered the John B. Murphy oration on surgery. Sir Squire Sprigge, editor of *The Lancet*, the journal of the British medical profession, gave the Hunterian oration and had conferred on him the Honorary Fellowship of the College. Dr. Franklin H. Martin of Chicago, the president-elect, Dr. George David Stewart of New York, the retiring president, and Dr. William J. Mayo of Rochester, Minn., also addressed the general meetings of the college. Surgical clinics were held in Boston hospitals during the week, when the latest and best methods of performing operations were demonstrated by the leading surgeons of America.—*Science Service*

THE CHEMISTRY OF THE RED AND BLUE PIGMENTS OF FLOWERS AND FRUITS. PART III

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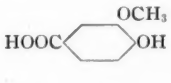
Methylated Anthocyanins and Anthocyanidines

Among the anthocyanins which were isolated by Willstätter were some from the flowers of the peony, petunia, wild mallow, hollyhock, and from the skins of the grape, huckleberry, and berries of the wild vine (Virginia creeper). The analyses of these substances convinced him that the corresponding anthocyanidines were mono or dimethyl ethers of cyanidine or delphinidine. The homogeneity of the glucosides was not beyond question in every case, however. Furthermore, upon attempting to locate the position of the methoxyl group by recognition of the fragments into which the anthocyanidine was split up by alkali fusion, it developed that the treatment was much too harsh and yielded inhomogeneous non-crystalline mixtures in which the methoxyl groups had evidently been partially removed by hydrolysis. For this reason Willstätter was unable to fix the position of the methoxyl groups in the anthocyanidine molecule, and his published reports on these cases indicated that he was well aware of their shortcomings.

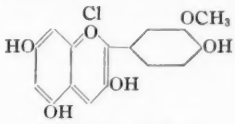
Willstätter in this work on methylated anthocyanidines had universally employed potash fusions at 140–250°. Early attempts to effect the complete degradation of cyanidine and delphinidine with strong aqueous solutions of alkali at 100–110° had apparently convinced him that while the phloroglucinol part of the molecule was readily obtainable the degradation of the other half of the molecule to a phenol carboxylic acid was incomplete. Upon attempting to find milder means of effecting this cleavage for the anthocyanidine methyl ethers, Karrer (Ref. 18) was surprised to find that mere boiling for several hours with 10–15% sodium hydroxide, or even 10% barium hydroxide, in an atmosphere of hydrogen not only sufficed to yield the phloroglucinol component but gave the unsaponified methyl ethers of the corresponding phenol carboxylic acids. Since this procedure gave homogeneous crystalline acids in which the position of the methoxyl group was known, Karrer was able to assign definite constitutions to the cases which Willstätter had been unable definitely to characterize.

As a result of this advance in technic Karrer offered convincing evidence that instead of a group of methylated anthocyanidines there have so far been isolated only two, a monomethyl ether of cyanidine and a dimethyl ether of delphinidine. The first is called peonidine from its occurrence as a diglucoside in the petals of the dark red peony: since alkaline hydrolysis by Karrer's method gives phloroglucinol and vanillic acid (XI) its structure

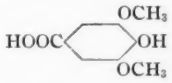
is definitely characterized as that represented in XII. The second on similar treatment gives phloroglucinol and syringic acid (XIII):



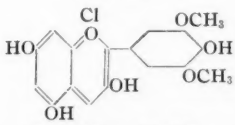
Vanillic acid
(XI)



Peonidine chloride
(XII)



Syringic acid
(XIII)



Syringidine chloride
(XIV)

the corresponding anthocyanidine is designated as syringidine (XIV).[1] During the progress of Karrer's work the synthesis of peonidine was reported from Robinson's laboratory (Ref. 5): the method employed was an extension of the general synthetic procedure which had already proved its worth by the synthesis of the three fundamental anthocyanidines. [See end of Part I, THIS JOURNAL, **5,** 1396 (Nov., 1928).]

In the course of effecting this simplification in our knowledge of the methylated anthocyanidines Karrer has shown that the pigments supposed by Willstätter to have been pure individuals, were really mixtures of varying proportions of two anthocyanins, one the well-known delphinin, the other a diglucoside of syringidine mentioned above. Indeed the pigment obtained from the huckleberry, and supposed by Willstätter to be a galactoside of a distinct monomethyl ether of delphinidine (myrtillidine), was found to consist of a mixture of delphinidine and syringidine galactosides and glucosides, the anthocyanidines being in about equal proportion. Althaein from the hollyhock contained a similar mixture of glucose compounds of the two anthocyanidines, but no galactose. In a group of three other pigments (oenin, cyclamin, and ampelopsin), syringidine forms 80–90% of the fundamental base. The pigment malvin, from the wild mallow, on the other hand, is notable as the most homogeneous of all the natural anthocyanins yet studied and consists exclusively of syringidine diglucoside. With these qualifications the occurrence of the methylated anthocyanins is indicated in Table IV. The parenthetical numbers refer to the bibliography at the end of this article.

[1] Karrer and Widmer (Ref. 25) have recently reported the occurrence in the primrose of an anthocyanin whose sugar-free pigment is a trimethyl ether of delphinidine in which two methoxyls are located as in syringidine: the third is in the phloroglucinol nucleus, but whether in position 5 or 7 has not yet been determined.

TABLE IV

ANTHOCYANIN DERIVATIVES OF METHYLATED ANTHOCYANIDINES

Peonidine (Cyanidine 3′-monomethyl ether)	*Syringidine* (Delphinidine 3′,5′-dimethyl ether)
MONOGLUCOSIDES	
	Ampelopsin—berries of wild vine (Virginia creeper) (23, 18)
	Oenin—grape (20, 23, 18)
	Cyclamin—cyclamen (18)
	Althaein—hollyhock (21, 18)
	Myrtillin—huckleberry (20, 23, 18)
DIGLUCOSIDES*	
Peonin—peony (22, 18)	Malvin—mallow (21, 18)

* Willstätter (5) has also reported petunin as a diglucoside of a monomethyl delphinidine: in the light of Karrer's work, however, it is possible that it may be found on reëxamination to be derived from syringidine.

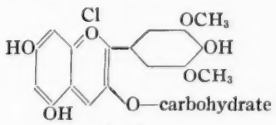
Oenin, the syringidine monoglucoside which imparts the beautiful blue color of the grape, has a special interest. Willstätter (20, 23) had concluded that it was a monoglucoside of a dimethyl ether of delphinidine given by him the designation oenidine. In a paper submitted on November 23, 1926, for publication in the *Helvetica Chimica Acta*, Karrer (Ref. 18) has shown that while Willstätter's general characterization is correct, the anthocyanidine possesses neither of the alternative formulas suggested by Willstätter, but is simply syringidine. Eighteen days before the deposit of Karrer's paper for publication, Anderson and Nabenhauer of the New York State Agricultural Experiment Station at Geneva, where experiments on the pigments of New York grapes have for some time been in progress, reported in the *J. Am. Chem. Soc.* (Ref. 29) that permanganate oxidation of the acetyl derivative of oenidine gave syringic acid and that the corresponding anthocyanidine consequently must possess the structure now designated by Karrer's term syringidine. This appears to add another to the already long list of instances in which substantially identical conclusions have been simultaneously reached by independent workers in widely separated laboratories.

The Position of the Carbohydrate Residue in the Anthocyanins

It has thus been shown that although some twenty-eight substances responsible for the colors of red and blue flowers and fruits have now been isolated, they are glucosides of only five individual anthocyanidines, and two of these are very simple derivatives of certain of the remaining three fundamental parent substances. Examination of Tables I and IV discloses,

however, that within any given group there frequently occur several isomeric combinations of the same anthocyanidine with the same number of molecules of the same sugar. In some of these instances it is probable that the anthocyanins will be found to be identical; in other cases, since the molecules are built up of the same units, the difference must involve the way in which these are put together. The answer to this new structural problem involves either the particular position at which the carbohydrate is attached to the anthocyanidine or the position of the carbohydrate structure by which it is attached, or both.

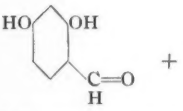
Karrer has recently reported (Ref. 19) great progress in the study of the first of these questions: *i. e.*, the determination of the position on the anthocyanidine structure to which the carbohydrate residue is joined. By means of oxidation with hydrogen peroxide he endeavored so gently to break up the molecule of malvin that smaller fragments containing the carbohydrate residue in a recognizable position might be obtained. While the effects produced were not exactly in this sense, their consideration led to the preliminary hypothesis that the carbohydrate was attached to position 3 of the anthocyanidine nucleus. This hypothesis was then brilliantly confirmed by another ingenious mode of attack involving methylation of the anthocyanins themselves, followed by subsequent removal of the sugar group and identification of the unmethylated position which it must have originally occupied. As a result it is now certain that in monardin, peonin, cyanin, and malvin at least, and probably in the case of all the other anthocyanins as well, the carbohydrate residue is attached through the position 3-hydroxyl of the anthocyanidine nucleus (XV).



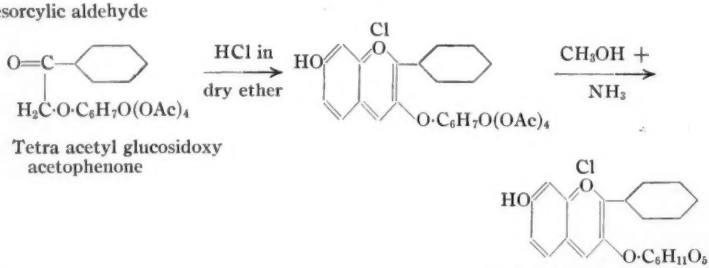
(XV)

Regarding the position of the carbohydrate by which it is attached to position 3 of the anthocyanidine nucleus, there is at present no experimental evidence. Nevertheless, using a relatively accessible glucose derivative, Robinson has been engaged in a study of synthetic methods by which a carbohydrate residue may be attached to the anthocyanidine molecule. Stated somewhat differently, he is engaged in finding out whether, in the general synthetic method employed for pelargonidine, cyanidine, and delphinidine, one component may be employed as a glucoside without suffering hydrolytic cleavage of the latter during the process. He has found that this may be done and has effected the synthesis of anthocyanidine monoglucosides carrying the sugar residue on the 4′, 7, and 3 positions, respec-

tively. (Ref. 26, 27, 28.) In the light of Karrer's demonstration the last of these cases represents the nearest approach so far reported toward the synthesis of an anthocyanin identical with the natural materials (Ref. 27), and is briefly outlined in the following sequence:



β-Resorcylic aldehyde



Tetra acetyl glucosidoxy acetophenone

3-Glucosidoxy-7-hydroxy flavylium chloride

This product resembles an anthocyanin in containing a glucose residue attached to position 3 of a flavylium nucleus. It differs from the known natural anthocyanins of the monoglucoside type by a hydroxyl deficiency both in position 5 and positions 3′, 4′, or 5′ of the phenyl group. It may also differ in the position by which the carbohydrate is attached to the anthocyanidine nucleus. It is apparent, however, that as the development of experimental methods permits the substitution of resorcylic aldehyde by phloroglucin aldehyde and of acetophenone derivatives by suitably substituted hydroxy homologs, the synthesis of a true anthocyanin will be brought closer and closer. Robinson has so masterfully surmounted the tremendous experimental difficulties already encountered, however, that it seems not unreasonable to suppose that in due time he will attain his initial objective.

Summary

The pigments responsible for the red and blue colors of flowers and fruits belong to a group of glucosides designated as anthocyanins. Twenty-eight individual members of this group have so far been characterized by the researches of Willstätter in Berlin and more recently by those of Karrer at Zürich. These anthocyanins possess both acid and basic properties and their color in the plant cells depends mainly upon their mode of combination. Their salts with acids are red while their metallic salts

with bases are blue; when in the neutral state the pigments are purple. In addition the color of the flower or fruit may be modified by variation in the concentration of a given individual, by mixtures of various members of the group, or by admixture of yellow pigments of a different nature.

By means of tedious extraction with various solvents the natural anthocyanins have been prepared in the crude state and purified through their beautifully crystalline salts with hydrochloric acid. Each anthocyanin may be split by gentle acid hydrolysis into two components, one a sugar, the other a sugar-free pigment resembling the original substance and called an anthocyanidine. In a few cases an organic acid is also produced. Qualitative examination of the sugar component shows that it may be either glucose, galactose, or rhamnose: quantitative study indicates that these may be combined with the anthocyanidine either as monoglucosides or diglucosides. It is found that the anthocyanidines from the 28 anthocyanins comprise only five individual substances. Three of these turn out to be homologous tetra-, penta-, and hexa-hydroxy derivatives of one fundamental structure called flavylium chloride. They are known, respectively, as pelargonidine, cyanidine, and delphinidine and constitute the bases of twenty-one anthocyanins. Of the two remaining, one is a methyl ether of cyanidine: the other is a dimethyl ether of delphinidine: these are found in the remaining seven anthocyanins.

This simplification has invited synthesis at which Robinson in England has been particularly successful. Pelargonidine, cyanidine, delphinidine, and peonidine have been prepared and the methods thus evolved have been applied to the preparation of substances of the anthocyanin type. The preparation of the actual anthocyanins is evidently imminent and appears to be impeded only by experimental difficulties and by insufficient data regarding the mode of combination between the anthocyanidine and the sugar. Karrer has recently shown, however, that position of the anthocyanidine to which the carbohydrate is attached. The point by which the sugar itself is fastened is still to be reported.

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(5) Nolan, Pratt, and Robinson, "Pyrylium Series XI. A Synthesis of Peonidine Chloride (and Pelargonidine Chloride)," *J. Chem. Soc.*, **1926**, 1968–71.

(26) A. Robertson and R. Robinson, "The Synthesis of Anthocyanins. I" *J. Chem. Soc.*, **1926**, 1713–20.

(27) A. Robertson and R. Robinson, "The Synthesis of 3- and 7-Glucosidoxyflavylium Salts. II," *J. Chem. Soc.*, **1927**, 242–7.

(28) A. Robertson and R. Robinson, "The Synthesis of Anthocyanins. III," *J. Chem. Soc.*, **1927**, 1710–17.

(29) Anderson and Nabenhauer, "The Anthocyanin of Isabella Grapes," *J. Am. Chem. Soc.*, **48**, 2997–3003 (1926).

(30) Willstätter and Mieg, "VIII. The Pigment of the Wild Mallow," *Ann.*, **408**, 122–35 (1914).

(31) R. Willstätter, "The Relationship between Anthocyans and Flavones," *Sitzb. preuss. Akad. Wiss.*, **1914**, 769–77 (1914).

(32) Willstätter and Schmidt, "The Synthesis of New Anthocyanidines," *Ber.*, **57**, 1945–50 (1924).

(33) Karrer and Salomon, "III. The "Safran" Pigments," *Helv. Chim. Acta*, **10**, 397–405 (1927).

Bureau of Standards Begins Technical Courses. A course of instruction in Einstein's theory is now being given at the U. S. Bureau of Standards, Washington, D. C., by Dr. Paul R. Heyl. It is one of a number of educational courses on various technical subjects pertaining to physics, mathematics, and chemistry, offered for the benefit of young men and women on the Bureau's staff, as well as for outsiders. The courses were begun twenty years ago under the authority of a joint resolution of Congress opening the government's bureaus for research and educational purposes. Besides Dr. Heyl, the instructors are Dr. T. L. de Bruin, of the University of Amsterdam; Dr. Tobias Danzig, of the University of Maryland; Dr. L. H. Adams of the Geophysical Laboratory, and others. Fees for the courses are charged in order to place them on a self-supporting basis, and to tide over lean years. The courses are under the general direction of an educational committee, of which Dr. L. B. Tuckerman is chairman, and from which information can be obtained.—*Science Service*

X-Ray Movie Camera Shows Inner Secrets of Growth. The inner secrets of the growth of a rosebud, as it slowly unfolded through a three-day period, have been recorded on a motion picture film by means of a new x-ray movie camera invented by Arthur C. Pilsbury, Berkeley naturalist-photographer. The potted rosebush was placed before the camera, and every five minutes for 72 hours a new 4-inch film was moved into place and exposed to the rays as they passed through the bud. At the end the inventor had 200 feet of film portraying the whole history of the flower's unfolding, down to the last detail of inner structure. This will reduce to 50 feet of ordinary motion picture film. It is planned to make use of the new camera for many scientific investigations; one project is to get a continuous history of the knitting of broken bones.—*Science Service*

KNOW YOUR FOODS. II. GRAHAM BREAD*

H. A. SCHUETTE, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN

In a previous discussion we indicated that butter's chief competitor—oleomargarine—is the product of French ingenuity, that it was first made during the period of the Franco-Prussian war, and that it got a start, so to speak, on the wrong foot with the result that it has not entirely escaped from the prejudice resulting from the frauds which were once practiced with it, although this food product is now being made from the purest of raw materials in sanitary factories under most strictly guarded and government-supervised conditions. We also stated that it has about the same degree of digestibility and energy value as butter, and that when milk is added as one of the ingredients of this synthetic food product, a certain degree of vitamin potency is given it.

Courtesy of "National Cyclopedia of American Biography"

Having introduced this series of discussions on "Know Your Foods" with one on a "spread" for bread, we next take up the subject of a particular bread itself.

What do you know about the origin of the term "Graham flour?" Much of what the journalist calls "human interest" surrounds the origin of this name although the history of the flour itself has been lost in antiquity.

When wheat was first ground for human consumption the product obtained was an unbolted wheat meal. This unbolted wheat meal was used for bread-making for centuries. In the course of time, however, as man became more fastidious about the appearance of his food, attempts were made with more or less success to produce a whiter and more attractive product. To do this it was necessary to remove the bran, which consists of the coarser particles of the wheat kernel. Gradually, by the use of improved processes of sifting, more of the bran was removed with the result

* A lecture by radiophone broadcast from station WHA, University of Wisconsin, February 29, 1928.

that the flour became more uniform in appearance and whiter in color. Although this flour was crude as compared with our modern so-called "patent flour," yet it contained very much less mineral constituents than the unbolted wheat meal of former times.

Highly milled, or "patent," flour is now known to be one of the most deficient foods which enters into the human diet. It is rather poor in protein, and this of a poor quality. Lime, phosphorus, sodium, chlorine and iron are there in insufficient amounts. Of the element magnesium it probably has a sufficiency. From the standpoint of human nutrition it is also significant that the anti-scorbutic vitamin *C* is lacking, that it is poor in vitamin *A*, and that factor which prevents rickets. And why not? The ground meal has been "purified" of these all-important constituents.

In or about the year 1839 there appeared a book, "Science of Human Life," by one whose activities as a writer and lecturer on dietetics were subsequently to cause, in a sense, a return to the use of that flour which modern milling methods once threatened to make obsolete. Existing knowledge on matters of nutrition was somewhat empirical at that time, but we now appreciate the fact that he was correct in many of his theories. In this respect he lived almost a century ahead of his time.

This was Sylvester Graham. Born in 1794, his was a life span of only 57 years for, though he preached longevity, fate, it seems, did not accord him this distinction. He spent his life in the New England states. Posterity will remember him as a dietarian although dietetics was not the field for which he had prepared himself. He was ordained a Presbyterian minister but did not follow the ministry, preferring rather to lecture and to write on medical subjects. He was an ardent advocate of temperance reform and vegetarianism, having persuaded himself that a flesh diet was the cause of all ills. And not only did he urge against the use of meat, but also stimulating seasonings, condiments,t ea, coffee, pastry, tobacco, and liquor.

Graham began a nation-wide agitation, soon after the appearance of his book, seeking a return to the use of bread made from the whole of the wheat, ground but not bolted, for he was convinced from his own experiences and that of previous ages of the efficacy and value of this type of bread.

From that time to this, unbolted wheat meal has been popularly known as "Graham flour," a definition acceptable to the federal pure food law enforcement officials and supported by American, British, and French scientific authorities.

The Bureau of Chemistry of the U. S. Department of Agriculture some years ago made a survey of the Graham flour industry and concluded that although a large percentage of the so-called Graham flour on the market is made by mixing inferior grades of flour with bran, there are a great many millers who still make Graham flour in the original way, which is by grind-

ing whole sound, clean, fully matured, air-dried wheat kernels either on stones or on rolls without bolting.

There is so much of interest in Graham's "Science of Human Life" on whole-wheat bread that we are tempted to make a few brief abstracts therefrom. For example, the author held to the belief that the ancients recognized that the bread which was made from whole-wheat flour[1] was more conducive to general health and vigor and better adapted to nourish and sustain than that made from highly milled flour. In the writings of Hippocrates, who is recognized as the father of medicine, he saw a recommendation for bread made from unbolted wheat in that it was stated that such bread had a salutary effect upon the bowels. In this commendation he found a parallel in his own practice for he had noted the efficacy of whole-wheat bread in all disorders of the stomach and bowels stating that "thousands of individuals . . . . . have been benefited by using the coarse wheaten bread instead of that made of superfine flour," and they are "living witnesses of the virtues of that bread."[2] Graham also quoted Baron von Steuben as saying that the "peculiar healthfulness of Prussian soldiers was in a great measure to be attributed to their ammunition bread made of grain, triturated or ground, but not bolted, which was accounted the most wholesome and nutritious part of their rations."

He turned also to English history for proof of the virtues of whole-wheat bread. Toward the close of the eighteenth century, England, as a result of her war with France, found her grain supply dwindling. Parliament, in order to conserve and extend the wheat supply, passed an act which made it obligatory that the army at home be supplied with bread made of unbolted wheat meal. The Continental Army was to receive, what it was believed to be, the better flour. Those soldiers who were supplied with such bread were at first greatly displeased, we learn, and refused to eat it, and even threw it away in great rage. However, so Graham reported, "after two or three weeks they began to be much pleased with it and preferred it to the fine-flour bread." The army surgeons and officers, noting a marked improvement in the health of the soldiers, "publicly declared that the soldiers were never before so healthy and robust and that diseases of every kind had almost entirely disappeared from the army." Publicity given this fact by the newspapers, coupled with the recommendations of the medical professions, soon led to the universal use of this bread by the civilian population of many a town. The habit was not to become permanently ingrained, however, because of heavy importations of fine flour from America, of larger crops at home, and of the removal of the restrictions which Parliament had placed upon the consumption of wheat flour.

[1] J. A. Le Clerc and B. R. Jacobs, "Graham Flour," U. S. Dept. Agric., Bur. Chem. *Bull.* **164,** 7 (1913).

[2] "Science of Human Life," **1839.**

THE

GRAHAM JOURNAL,

OF

HEALTH AND LONGEVITY.

DEVOTED TO THE PRACTICAL ILLUSTRATION OF THE SCIENCE OF HUMAN LIFE AS TAUGHT BY SYLVESTER GRAHAM AND OTHERS.

DAVID CAMBELL, EDITOR.

VOL. II.

Boston:
NO. 9, WASHINGTON STREET.
New York:
NO. 126, FULTON STREET.
1838.

FRONTISPIECE OF GRAHAM JOURNAL

That Graham's teachings made for him a following is apparent by the establishment of so-called temperance or Graham boarding houses in Boston and the city of New York. Here those who wished to follow the daily regimen of Graham found every opportunity of doing so. "Early to bed, and early to rise" seems to have been a fundamental condition which all who would live here accepted. Frequent baths were encouraged not of the orthodox tub variety, but showers plentifully supplied with cold water. But let the advertisement tell the story.

> At 23, Brattle Street, Boston. Transient company furnished with Board and Lodging, or their meals without lodging. Tickets for single dinners for sale at this office. Regular hours for meals are 6, 12, and 6 o'clock. The shower bath is constantly supplied with water and is free to all.[3]

An ambitious attempt was made by David Cambell in 1837 to establish in Boston a journal through whose columns were to be disseminated and factually illustrated the science of human life as Sylvester Graham lived and taught it. Its full title was THE GRAHAM JOURNAL OF HEALTH AND LONGEVITY, "designed to illustrate by facts, and sustain by reason and principles, the science of human life as taught by Sylvester Graham." The publication failed after a struggle of several years because of a lack of enthusiasm on the part of its subscribers to give it financial support.

Among the numerous items in its pages which have perhaps an historical interest is the following characteristic advertisement and several recipes for making Graham bread.

BRYANT & CLARK

> Dealers in Grain and Meal, Haverhill Street, near Warren Bridge, Boston, Graham meal constantly on hand.[4]

One of the "old modes" of making Graham bread is described in a letter dated Albany, N. Y., Sept. 22, 1837. It was written by a miller to a flour merchant of Boston.

> The flour, together with a suitable quantity of yeast to ferment—should be moulded up thin and put into the baking-pans *immediately* (in about one-half the quantity you expect the size of the loaf after being baked). As soon as it is in the pans put it in a place of moderate heat, and let it stand undisturbed until fermented (raised) sufficiently to bake—then put it in an oven of rather more intense heat than would be necessary to bake superfine flour bread. *Miserable* bread is often made from the *best* of Graham flour—and it is because it is raised and then *moulded* and baked in an oven without sufficient heat. *Moulding* after raising *spoils* it.[5]

More specific in its directions is the following one:

[3] *Graham Journal*, **2**, 208 (1838).
[4] *Ibid.*, **1**, 160 (1837).
[5] *Ibid.*, **1**, 212 (1837).

For the sponge, take one quart of water, blood warm or about 100°F., add one teaspoonful of salt, stir in coarse wheat meal till it becomes a thick batter, then if it is kept at about a temperature of 80 or 90° it will ferment sufficiently in from four to six hours or if prepared in the evening let it remain at about 60° till morning, then add two or three quarts of warm water with a suitable proportion of the wheat meal, mould it in pans, and in about one hour it will rise sufficiently for the oven. In this way, with proper care and experience, the best of bread may be made without any pearl-ash, yeast, molasses or milk. Some use a very little saleratus to prevent all acidity in the bread, but that had better be avoided by having the dough in the oven before the fermentation proceeds too far.[6]

Such is the story of how the use of an ancient wheat meal was revived. From the standpoint of nutrition, its use is physiologically sound. Viewed in the light of the conservation of food, since the nutrients of bran are but poorly utilized by man and since the embryo impairs the keeping quality of flour, thought might very well be given the opinions advanced by some[7] that its universal use to the complete exclusion of highly-milled flour would constitute in a sense an economic waste of a food which could better be utilized on the farm in the production of meat. To discard white bread completely from the American diet because of a fear that, when it forms an unduly large proportion of the diet of children, its vitamin deficiencies might lead to malnutrition, seems hardly necessary because the food habits of the American people are such as to make cases of this kind comparatively rare.

[6] *Graham J.*, **1**, 102 (1837).

[7] Osborne and Mendel, *J. Biol. Chem.*, **37**, 557–601 (1919).

Artificial Coal Made from Wood Substance. Cellulose and lignin, the two principal constituents of wood, have been converted into artificial coals practically identical with natural coal found ready-made in the ground, Dr. Friedrich Bergius of Heidelberg, Germany, announced recently to the Second International Conference on Bituminous Coal. In 1926, Dr. Bergius at the first Coal Conference told how he had made synthetic gasoline, oil and other products out of coal and since then the German Dye Trust has utilized his process for producing commercially thousands of tons of synthetic motor fuel.

During theoretical researches upon the constitution of coal conducted from 1910 to 1913, Dr. Bergius first transformed cellulose into coal on a laboratory scale. This accomplishment led to the hydrogenation of coal under high pressure and during the fifteen years of developmental work upon this process further theoretical work on coal formation was not undertaken. In the past year, however, Dr. Karl Schoenemann of the Bergius laboratory has manufactured several pounds of the artificial coal from cellulose and smaller quantities from lignin. Chemical analysis and conversion of the artificial coal into products similar to those produced from natural coal have convinced Dr. Bergius that the substance made from the wood elements is a real coal.

Making of coal from wood and the production of oil from coal provide hints of the processes leading to the formation of these substances in nature.—*Science Service*

SOME ILLOGICAL IDEAS THAT PERSIST IN ELEMENTARY CHEMISTRY

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For many years the science of chemistry has grown with such amazing rapidity that many things in the chemical literature of one decade are little more than curiosities to the chemists of the next decade. Continual modification of even elementary texts is necessary, not only to incorporate new facts as they are discovered, but also to present the fundamentals of the science in a more and more logical and strictly scientific fashion. As a consequence of this situation, there are many desirable changes that are slow to come to the attention of authors when old textbooks are revised or new ones written. The purpose of this paper is to discuss a few of the topics that are often treated, in a manner scarcely in keeping with a modern scientific point of view, in texts and in journals dealing with elementary chemistry.

No claim of originality is made, for all of the topics presented here have been discussed elsewhere or have been partly, at least, clarified in many recent textbooks; but are so treated in some widely used texts and by some teachers that attention may well be called to them again. Students who have had courses in high-school or college entrance chemistry often indicate by their statements that they have acquired illogical and even misleading ideas as facts or supposedly logical theories. Likewise no claim of completeness is made for this short criticism. Almost any text contains many questionable statements that are not mentioned here: partly because of our insufficient knowledge of the substances in question; partly because no text can keep abreast of some of the modern theories that are changing from day to day, such as the theory of strong electrolytes, and of atomic structure.

The first example is the use of the terms *burn, combustion, support combustion.* In popular language, combustion means the rapid reaction of oxygen with something else to produce a visible flame, the oxygen "supporting the combustion" and the other substance "burning." This definition can be stretched somewhat to include a few other reactions; but the terms do not lend themselves to a description of many reactions, or even any reactions in a really scientific manner. A few of the recent texts treat the reactions of oxygen in a careful, scientific fashion. The following is quoted from a well-known text: "Violent union with oxygen is called, in popular language, *combustion,* or burning. Yet, since similar vigorous interactions with other gases are common, the term has no special scientific significance." "Sulfur, when raised in advance to the temperature necessary to start the reaction, unites vigorously with oxygen.....The mode of experimentation can be changed and the oxygen

led into sulfur vapor through a tube. The oxygen then appears to burn with a bright flame, giving the same product as before."

But many high-school and college texts are by no means above criticism in their presentation of this topic. Often one section is thoroughly revised and the older treatment left in the remainder. The tendency used to be to list as an important chemical property (!) of each new gas studied, its ability to "burn" or "support combustion." On the basis of this "property," substances are divided into two classes: the first including some metals, hydrogen, methane, acetylene, wood, a candle, etc.; the second, oxygen, chlorine, nitrous oxide, and a few other gases. The first may be a gas, liquid, or solid; the second must of necessity be a gas. A few of the older, and several of the modern texts carefully point out that the rôle of the two may be interchanged if both are gases; but even this revision has not been entirely accepted.

The emphasis placed on these terms to describe properties of substances is shown in a recent book of questions intended chiefly for use in high-school chemistry.[1] The questions "does it burn? does it support combustion?" are asked in one form or another about oxygen, nitrogen, hydrogen, chlorine, hydrogen sulfide, sulfur dioxide, carbon dioxide, and ozone. They are not asked about the oxides of nitrogen, ammonia, fluorine, and carbon monoxide. (The rare gases, organic gases, liquids and solids covered in the book are omitted in the above analysis.)

In a recent article in THIS JOURNAL,[2] attention is especially called to the difficulty of teaching pupils to discriminate between "burning" and "supporting combustion." In tests extending over several years it was found that 96% of the pupils could be taught to underscore "supports combustion" in a multi-choice question on the properties of oxygen, when it was specifically stated that only one choice was correct; but in a similar multi-choice question with two or more correct choices, 60% persisted in underscoring "burns" as well!

It seems illogical, even in a high-school course, to place such emphasis on the teaching of "properties" that have so little scientific significance. Any one can easily convince himself that oxygen really does burn (in the same sense that illuminating gas, let us say, burns in air) and consequently the student who says that oxygen burns is perfectly correct, if he knows the evidence that supports his contention. Ordinarily hydrogen is said to burn, but not to support combustion. But fill an inverted jar with hydrogen; ignite this at the mouth of the jar, and insert a jet from which a slow stream of air or oxygen is issuing. A flame will be

[1] Cook, "New Type Questions in Chemistry," Globe Book Co., New York City, 1927.

[2] Malin, THIS JOURNAL, 5, 208 (Feb., 1928).

carried up into the jar by the jet, and the oxygen will be seen to burn, while the hydrogen supports the combustion (if one cares to use those terms). If a mixture of oxygen and hydrogen is ignited, no one can say which gas "burns" and which "supports the combustion."

Every freshman chemistry class in many colleges is shown an experiment to demonstrate how illuminating gas and air can be interchanged in a flame. Many textbooks describe the experiment.[3] After seeing this experiment, one can scarcely ask a class to believe that air will not burn!

It is a common experiment to introduce a hydrogen flame into a jar of chlorine and thus show that chlorine "supports the combustion" of some substances. Why is not the procedure varied more often, and a jet of chlorine introduced into an inverted jar of hydrogen, which has just been ignited? Another usual experiment is to thrust a lighted candle into a jar of hydrogen, to show that the latter does not "support combustion." Of course it does not support the combustion of something with which it cannot possibly react. Substitute for the candle something which reacts vigorously with hydrogen, with visible production of heat and light, and an entirely different result is obtained.

Carbon dioxide is generally listed as a gas which will not "support combustion." But magnesium will react vigorously in an atmosphere of carbon dioxide, visibly producing heat and light, and forming magnesium oxide and carbon. Sodium "burns" almost as brilliantly in carbon dioxide as in air. Nitrous oxide is generally listed as "supporting combustion." If magnesium "burns" in an atmosphere of nitrous oxide, the reaction is exactly analogous to that with carbon dioxide. The two gases should not be classified differently just because one will react vigorously with more substances than the other.

The point of the above discussion is not, naturally, to insist that it is incorrect to use the terms in question at all. These terms describe certain phenomena in familiar, easy-to-understand language. But questions and statements of students who have had a beginning course in chemistry make one feel that some caution should be exercised in the treatment of this topic. There is no justification for placing undue emphasis on burning and supporting combustion as chemical properties of substances. There are more logical ways to describe the phenomena from a scientific viewpoint.

A second example is the use of the terms *oxidation* and *reduction*. It is not intended to discuss oxidation-reduction reactions fully here; that has been done elsewhere, and many of the faults of the usual presenta-

[3] Kahlenberg, "Outlines of Chemistry," Macmillan, New York City, 1909, p. 32. Smith-Kendall, "College Chemistry," Century Co., New York City, 1925, p. 442.

tion pointed out as well.[4] The treatment of these terms in elementary texts has by no means kept pace with the expansion of their significance during recent years, no doubt because this expansion has been so rapid. Oxidation is still defined as *the combination with oxygen* and reduction as *the removal of oxygen* and these definitions the student seems to remember only too well. To be sure, in modern texts it is usually added that the terms in question are used in a wider sense, and fuller treatment is taken up later. Nevertheless, oxidation and reduction are almost invariably, after an elementary course, so closely connected in the student's mind with oxygen and hydrogen, either free or combined or *nascent*, that it is very difficult for him to acquire the modern viewpoint later. There are two apparent solutions to the problem: either change the name *oxidation* (except as a popular term for the reactions of oxygen), or modify the treatment in the elementary texts and courses to emphasize the scientific, not the popular use of the terms. The first has been proposed several times, but never accepted by any considerable number of chemists. The latter will be done eventually, but the introduction of such an idea is always slow. One difficulty is that the teaching of oxidation-reduction in the modern sense is usually postponed until so many complicated reactions have accumulated that pupils and teacher alike are swamped in them and must wade out of the difficulty somehow. Of course, the proper thing to do in a high-school or college entrance course is to avoid the complicated reactions as much as possible, and certainly to refrain from trying to teach their full significance. But even in such a course students could be taught to recognize simple oxidation-reductions as such and the fundamental difference between these and *double decomposition* reactions.

Every text calls the slow union of iron with oxygen *oxidation*. But the student seldom learns that this reaction is also a *reduction*. The union of iron and sulfur, or of copper and chlorine, is seldom treated as an oxidation, certainly not as a reduction. When these reactions are first studied, it is too early for the student to get any idea of the general significance of the terms oxidation and reduction; and it is unfortunate that he should receive the almost indelible impression that these terms are intimately connected with the addition and removal of oxygen. So many other simple reactions are studied that are chemically similar: the reaction of chlorine with metals, the decomposition of compounds by heating, the *displacement* reactions. It would perhaps be more logical to omit all mention of oxidation and reduction until these terms can be applied to all the above reactions; or, in a high-school course, to use them

[4] See Jette and LaMer, THIS JOURNAL, **4**, 1021–30 (Aug., 1927); 1158–67 (Sept., 1927). For a discussion and bibliography see Jette, "Oxidation-Reduction Reactions in Inorganic Chemistry," Century Co., New York City, **1927.**

only in their industrial connections. Several of the recent texts have attempted to remedy the situation but it is very difficult to modify long-established conventions.

Let us quote a few typical statements on this topic from high-school and college texts: "We may regard the liberation of the chlorine as the result of the oxidation of the hydrogen of hydrochloric acid. One atom of oxygen in the manganese dioxide oxidizes two molecules of hydrochloric acid." "Oxidation and reduction often occur simultaneously....." "Peroxides readily give up....(some of their)... oxygen.... to substances.... in other words, they are good oxidizing agents." "The potassium permanganate, which supplied the oxygen, is called the *oxidizing agent*. Since the permanganate *lost* oxygen, it was itself *reduced*."

The first statement above appeared in the older edition of a text that has been revised recently. This statement was modified, as were many others, to conform more nearly with the modern viewpoint. The new edition of this text contains an exposition of the modern theory of atomic structure and of the idea of electron interchange in chemical reactions; further on, in explaining the action of aqua regia, the authors have overlooked the statement that "the hydrogen of the hydrochloric acid is oxidized by the nitric acid!"

The above paragraphs bring up a third example—the classification of chemical reactions. Usually, when the pupil learns that iron and oxygen react to form iron oxide, he learns that this is typical of a large group of reactions called *combinations*. Soon he learns that there are other types of reactions—namely, decomposition, displacement, and double decomposition. It is true that most reactions can be classified in these groups but does this classification have any importance? It does not help the student to remember reactions and the similarities of such reactions as those of hydrochloric acid and zinc, of chlorine and turpentine, of bromine and ammonia, are scarcely elucidated by the observation that they are all *displacement* reactions. There are many other ways of classifying reactions that are equally, if not more, useful. For instance, it is often essential to know if a reaction is *endothermic* or *exothermic; oxidation-reduction* or *not; slow, fast,* or *instantaneous*. Reactions could also be arbitrarily classified according to the *phases* reacting; according to the *volume change;* as *homogeneous* or *non-homogeneous;* as *catalytic* or *non-catalytic*. Some of these classifications would be useful and some would not, to the elementary student; they all have as much fundamental significance as the usual *type* classification.

Sometimes the first two types mentioned above are called *synthesis* and *analysis*. Such use of these terms must be misleading to the student when he encounters them again later. Occasionally oxidation-reduction is given as a fifth type! No comment is needed. One college text,

however, takes especial care to teach that the first three types are all oxidation-reduction reactions and lists "other oxidation-reduction reactions" as the fifth type. And it is encouraging to note that the newer texts are inclined to place less emphasis on this classification of reactions—postponing it until later in the book and assigning it only a small amount of space.

The fourth and last argument concerns the time-honored discussion of *nascent* gases. The term *nascent* is a very convenient one, but for good reasons it has fallen into disrepute, and any use of it now must certainly be in a much modified sense. It is scarcely necessary in an elementary course to attempt to give a reason for such reactions as that between chlorine water and organic dyes. It is natural to want to *explain* everything; but explanations must either be in terms of facts, or logical deductions from facts. The *nascent* gas theory is not logical. There is no direct or indirect proof that when copper and nitric acid react, *nascent* hydrogen is formed, and then proceeds to react with more nitric acid. There is likewise no evidence that chlorine water in the dark, in the presence of a dye, liberates oxygen, which is in such a different state from ordinary oxygen that it immediately attacks the dye. In class one day the following equations were on the blackboard:

$$2HOCl \longrightarrow 2HCl + O_2$$

$$2H_2O + 2Cl_2 \longrightarrow 4HCl + O_2$$

One student contended that the equations must be written with O for oxygen instead of O_2 because *nascent* oxygen is liberated. The student had confused what he had been taught about nascent oxygen; but this is an example of the thing that leads to the old argument between college and high-school teachers, discussed recently![5]

One can scarcely believe, knowing the chemistry of gold and its compounds, and the facts and theory of oxidation-reduction cells, that gold dissolves in aqua regia because of its *nascent* chlorine. One text, as mentioned before, says, "The hydrogen of the hydrochloric acid is oxidized by the nitric acid:

$$3HCl + HNO_3 \longrightarrow 3Cl + 2H_2O + NO\uparrow"$$

If *nascent* chlorine is formed in this mixture, it cannot remain *newly born* indefinitely; and how can the introduction of a piece of gold start its liberation again? Gold is dissolved if chlorine gas is bubbled into nitric or hydrochloric acid surrounding the metal; even by chlorine water alone.

It can easily be shown that when chlorine is dissolved in water or hydrochloric acid, the formation of chlorine with a higher energy content than ordinary chlorine is a thermodynamic impossibility. No one has postu-

[5] Editorial, THIS JOURNAL, **5**, 5–6 (Jan., 1928).

lated *nascent* chlorine in such mixtures; the *nascent* gas formed is supposed to be oxygen. As a matter of fact, the solution of gold in such mixtures depends on two factors: its oxidation to the trivalent state, and the removal of the trivalent ion by combination with chloride ion. Consequently the ease of solution depends upon the character of the oxidizing agent and the concentration of chloride ion. The solution of gold in aqua regia and in cyanides has been treated in detail by Jette.[6]

Let us again quote a few typical statements: "Elements at the moment of their liberation from a compound are for a short time more active than otherwise. They are said to be in the *nascent state.*" "..... the chlorine combines with the hydrogen of the water and the oxygen set free combines with the reducing material present." "Chlorine is able to decompose water in the absence of light, provided there is present an oxidizable substance."

There are more fallacies in the above statements than that of the nascent gas theory; but eventually they will be eliminated as the treatment is revised to make use of the knowledge investigation has gained.

[6] *Loc. cit.*, pp. 102–105.

Growth in Cold Improves Linseed Oil Quality. The scientific secret of the higher quality of linseed oil derived from northern grown flax has been traced by Prof. W. Iwanof of the Institute of Applied Botany at Leningrad, Russia. Experiments on flax seed gathered from various climates, from the south to the north of Russia, were checked by experiments on seed from plants grown in artificial climates under laboratory control. In both groups of tests, the plants that grew and ripened their seed at lower temperatures and with less light yielded a higher percentage of linoleic acid, which is the stuff that makes linseed oil dry rapidly, thereby rendering it valuable in paints, linoleum, etc.

Prof. Iwanof is of the opinion that, in general, northern climates are the better for forming quick-drying oils in growing plants, whereas southern regions, with more warmth and sunlight, favor the formation of oleic acid, characteristic of olives, pistachio nuts, citrus fruits, etc.—*Science Service*

Tiny Gland May Save Lives of Burn Victims. Victims of fires who have been severely burned may be saved from death by a substance from a tiny gland located at the base of the brain, according to Dr. Oliver Kamm of Detroit. This substance, Dr. Kamm has discovered, helps the tissues of the body retain water. According to the latest theories, death results from burns because the body tissues are dried out.

Lack of this substance may now be supplied by extracts from animal glands. This may prove of immense benefit in certain other conditions besides burns. For instance, the illness and shock after an anesthetic given during an operation are now thought by some to be due to drying out of the tissues.

Over or under activity of this gland, according to Dr. Kamm, may be partly responsible for certain diseases, such as a form of diabetes characterized by extreme thirst and excessive elimination of water.—*Science Service*

THE NOMENCLATURE OF HIGH-SCHOOL CHEMISTRY[1]

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Chemistry teachers have known for decades that one of their most difficult teaching problems was centered in the nomenclature of chemistry. The difficulty of getting students to learn the meanings of scientific terms has always been such as to demand the attention of college teachers, but in recent years high-school teachers, particularly of chemistry and biology, have found that this difficulty has developed into a most formidable problem.

As one of the outcomes of some three or four years of study of definitions found in high-school science texts,[2] some conclusions are offered with the hope that more interest in the problems of nomenclature will be aroused, and that some improvement may ultimately be brought about, at least in the field of high-school chemistry.

There are a number of major reasons why chemistry students have difficulty in acquiring an adequate understanding of the language of the subject.

Too Many New Terms

During the last three years there have appeared two or three valuable studies of the vocabularies of high-school texts, and these have clearly shown that chemistry texts[3] introduce many almost useless new terms, and thus unnecessarily increase the task of the pupil in high-school chemistry.

It is quite evident that high-school chemistry could be taught better and more easily if the number of new terms introduced could be reduced from the eight or nine hundred of the present average text, to five or six hundred. This is a task for the Committee on Chemical Education of the American Chemical Society, or some other authoritative body.

Teachers Often Careless

Teachers are often careless in the use of chemical terms and thus induce carelessness and loose thinking on the part of their pupils. Some teachers use the term *substance* when they mean *compound*, and the term *body*

[1] From a lecture, "Defining the Problems Involved in the Teaching of High-School Chemistry," delivered August 8, 1928, at the Second Institute of Chemistry at Northwestern University.

[2] "Encyclopedic Dictionary of High-School Science Terms," by J. O. Frank and H. K. White, edited by S. R. Powers and published by P. Blakiston's Son & Co., shortly to be announced.

[3] "The Technical Vocabularies of the Public School Subjects," Luella C. Pressy, Ohio State University, and "The Vocabularies of High-School Science Texts," S. R. Powers, Teachers' College Record, Vol. XXVIII (November, 1926).

when they mean *substance*. Others refer to *glucose* as *sugar* instead of classifying it as *a sugar*, and many call *aluminum sulfate, alum*. There are perhaps a hundred words which are quite commonly carelessly used. The effect of such teaching is to make the pupils even more careless and inaccurate than their teachers, and to greatly increase their difficulties when they go to college or come into contact, elsewhere, with good teachers.

Many Terms Have Same Meaning

In many schools, chemistry classes have access to a number of different reference texts and so they become acquainted with the terms used by many different authors. Pupils soon find that many different terms have almost, if not exactly, the same meaning[4] and that some authors seem to prefer one term to express a given idea, while others never use that term but express the idea with words which are entirely different. Pupils are confused when they discover such a situation, and often spend much valuable time trying to discover differences in meaning which do not exist. Undoubtedly, too, they become more or less discouraged because of inability to settle upon the final meanings of terms or to find terms with which to express exact ideas.

Terms Used in Other Sciences

A serious difficulty arises from the fact that many terms used in chemistry have been used in general science, physics, or biology, which preceded the chemistry. Frequently, the meaning was quite different in the earlier science, but the pupil continues to think of the word in its old meaning. On the other hand, the teacher, being absorbed in his own subject, never suspects that his pupils are getting a different picture from his words than that which he is trying to paint. Clearly the teacher and the pupils simply do not speak the same language, until they are in agreement as to the meaning of the terms used. Consider the word *normal*. Many pupils have difficulty in learning the meaning of this term in chemistry. They persist in trying to think of normal solutions as solutions which are perfectly regular in behavior. The word *condenser* refers to one thing in chemistry, and quite a different thing in electricity, yet high-school pupils try to apply in chemistry the meaning given the term in physics, and the teacher often fails to understand why they fail to grasp the meaning of the term. Words, which have been used in sciences previously studied, deserve special attention from chemistry teachers. Care should be taken to explain the *new* meaning which the *old term* has in chemistry.

[4] In six different texts the same idea is expressed by the following terms: *equivalent weight, combining weight, combining number, equivalent, chemical equivalent, electrochemical equivalent, hydrogen equivalent, reacting weight, gram equivalent*, etc.

Many Faulty Definitions in Chemistry Texts

Some texts, both high-school and college, seem deliberately to avoid giving definitions of chemical terms. These texts usually *explain* terms but do not actually define them. Undoubtedly, such texts fail to assist pupils to get accurate conceptions of the very units out of which is built that system of thought which we call chemistry.

Some texts attempt to give definitions of all important terms but fail to give good definitions, for various reasons. Sometimes the language is too technical and cannot be understood by the high-school pupil.[5] In other cases, the definition is quite inadequate[6] and in a large number of still other cases the definition is simply wrong. One can begin to realize the difficulty confronting the high-school pupil attempting to get a clear understanding of the meanings of chemical terms, if he will compare definitions as given in different texts. Select three texts at random and compare definitions of such terms as *ionization*, *critical temperature*, *alloy*, *vapor density*, etc. These definitions will be found to differ widely in about every possible way, except that in the majority of cases they will not give to the high-school pupil an adequate statement of the true meanings of these terms.

Terms Incorrectly Used

Many texts assign an incorrect meaning to one class of terms, because the terms of this class are so often misused by chemists and by the public. This statement demands some explanation. In the evolution of the various sciences, their transition from pseudo sciences into true sciences was marked by the introduction of two things: *accurate measurement*, and *means of exact expression*. As chemistry emerged from alchemy, words and terms began to have more exact meanings. Unfortunately, progress in this direction has always been marked by periodic reverses and today we find many remnants of primitive periods in our nomenclature, many survivals of bygone days. There was a time when the exact composition of a number of similar compounds was unknown and these compounds were given a class name. When, in the course of time, the composition of the various members of the class was discovered, it usually happened that the most important member of the class was called by the class name. Thus, the term *alum* was originally applied to any of a class of astringent double sulfates of aluminum, and some monovalent metal, crystallizing in similar fashion, because the differences between

[5] This is particularly true of definitions in high-school texts written by college teachers.

[6] This definition occurs in one text: *"Sublimation is the volatilization of a solid without passing through the liquid state."* This author would probably define distillation as the volatilization of a liquid.

those in the class was not known. When the exact composition of the various compounds in this class became known, the most important of *the alums*, namely, *potassium aluminum sulfate*, was commonly known as *alum*. This custom of calling the most important member of a class by the class name has been generally used in pharmacy and in the industries for decades, and the list given below will show how well established such usage has become. The meaning given is that which is meant when no qualifying words accompany the term.

Alcohol, means ethyl or grain alcohol and no other alcohol.
Aldehyde, means acetaldehyde and no other aldehyde.
Alum, means potassium alum and no other alum.
Carbide, means calcium carbide and no other carbide.
Ether, means sulfuric ether, and no other ether.
Salt, means common salt or sodium chloride and no other salt.
Sugar, means sucrose or cane sugar and no other sugar.

This list might be extended to include several hundred terms but the words given have been so frequently misused, both in texts and in common usage, that they are given as "terrible examples." It ought to be said here that the misuse of these terms is not always the result of carelessness or ignorance. Sometimes an established interest deliberately brings about the legal wording of a definition—without regard to the true meaning of the term defined. All the terms given above have been misused and incorrectly defined by people who have had some selfish motive: *wood alcohol* has been called *alcohol*, *formaldehyde* has been called *aldehyde*, *ammonium alum* and even *anhydrous sodium aluminum sulfate* have been called *alum*, etc. One text in describing petroleum ether confuses it with ether or sulfuric ether and ends with the statement that the compound is widely used in hospitals. Patent medicine vendors include other salts under the term *salt*, and there is a definite movement on the part of certain interests to secure legal permission to use the term *sugar* to indicate the presence of glucose in food products. A long step forward will be taken when it is definitely understood that the chief member of a class may be known by the class name, but that all others must be known by their specific names.

Some confusion as to the meanings of terms has arisen because some authors give too much attention to the *original* meaning of the term. Chemistry has changed so rapidly and so completely in many of its branches that in the light of the new knowledge many terms have come to have a meaning quite different from that of a half century ago.

It is hoped that this discussion of some of the causes of difficulties of teaching the correct use of chemical terms, will lead to comments from others and perhaps ultimately to progress toward the solution of one of the chemistry teacher's most difficult problems.

FINDING THE SUPERIOR HIGH-SCHOOL CHEMISTRY STUDENT[1]

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No argument is needed to convince the thoughtful teacher that the more capable of his students are the ones who will, if properly trained, make the greatest returns to the community which educates them. From the days of the "Old Dominie" who was constantly alert to discover the "lad of pairts" to the present with its Terman patiently following "One Thousand Gifted Children," teachers have sought to discover the child of promise. Why a chemistry teacher should enter upon such a crusade has been considered by one of the authors in previous papers.[2,3]

The present paper is a report upon a coöperative project entered into by a number of high-school teachers[4] in an effort to discover, if possible, a way of finding the student who would prove exceptional in chemistry. A later paper will attempt to present plans for keeping such students working up to the limit of their superior abilities.

Previous School Grades and Success in Chemistry

It was the practice, even before the modern era of testing began, for the forward-looking teacher to anticipate the classroom behavior of her pupils through a study of their records in previous courses. The assumption, in such use of records, was that a good past record indicated a good future performance. The validity of that assumption has not been verified. Correlation values are assumed to be more accurate than the qualitative estimates of teachers as measures of such relationship and will therefore be used throughout the paper.

The relation of high-school grades to freshman college grades has been more generally determined than that between grades of one high-school subject and those of another. Jordan[5] found that the average grade for all four high-school years of 227 college freshmen gave a correlation of 0.54 with their average first-year college grades. Odell[6] reports the correlations between high-school and college chemistry, and high-school mathematics and college algebra and trigonometry to be above

[1] This study was made possible by the assistance extended by Professor Herbert Brownell, Chairman of the Department of Secondary Education, Teachers' College, University of Nebraska.

[2] THIS JOURNAL, **2**, 655–8 (1925).

[3] *Ibid.*, **3**, 1380–4 (1926).

[4] H. R. Smith, Lake View High School, Chicago, Illinois; Grant L. Stahly, Hastings, Nebraska; Martin V. McGill, Lorain, Ohio; D. Dale Davis, Manchester, Iowa; Mina Goehring, Teachers' College High School, Lincoln, Nebr.

[5] *School and Society*, **11**, 354–8 (1920).

[6] *Ibid.*, **25**, 702–8 (1927).

0.50. He says, however, "These correlations with the several high-school subjects . . . do not offer much help in predicting freshman success."

The teachers in this project made use of both ninth-year algebra grades and the tenth-year science grades as indicators of the quality of work which their students might be expected to do in eleventh- and twelfth-year chemistry. How significant this procedure was is revealed by the correlation values between ninth-year algebra and tenth-year science grades and the mid-semester chemistry grades. For ninth-year algebra with data for 204 students the correlation was 0.35 ± 0.043; for the tenth-year science for 51 students the correlation was 0.50 ± 0.09.

In this study the embarrassment faced, in trying to use the science grades as a surer index of promise in chemistry, was that but twenty-five per cent of the students had had tenth-year science. Seventy-two per cent of the students had had ninth-year algebra. From these values, Odell's statement[6] might well be paraphrased to say, "Tenth-year science and ninth-year algebra do not offer much help in predicting success in high-school chemistry."

Intelligence Tests and Success in Chemistry

It is common for schools which classify students according to ability to make such groupings by the aid of intelligence tests. The degree that such tests forecast success in any given high-school subject is, also, most tersely and accurately expressed by the correlation[7] found between the ratings from the test and the semester's or year's grades in that particular subject. Jordan[8] found that for 32 cases such correlation between Otis Intelligence Test and General Science was 0.502; Miller's Intelligence Test and General Science was 0.592; Alpha Army and General Science 0.596; and Terman and General Science 0.636. Rector[9] gets a correlation of but 0.28 between Alpha Army and science grades for 237 students. Hurd,[10] for ninety-one students, reports a correlation of 0.76 between a year's ratings in high-school physics and the average of Miller and Otis tests. One of the authors[11] found for 293 college freshmen a correlation of 0.56 ± 0.025 between their grades in first semester college chemistry and their Alpha Army test ratings. F. S. Breed[12] summarizes such studies by the statement, "Coefficients of correlation between intelligence scores and achievement scores cluster around 0.40 and 0.60." The lack of agreement among these correlations is very apparent. Just how much de-

[7] The Pierson constant is used throughout this paper.
[8] *J. Educ. Psychol.*, **13,** 419–29 (1922).
[9] *Ibid.*, **16,** 28–37 (1925).
[10] *Sch. Rev.*, **34,** 123–8 (1926).
[11] B. Clifford Hendricks, Unpublished data (1925).
[12] *Sch. & Soc.*, **15,** 406–9 (1922).

pendence may be safely placed upon them? To answer this another question should be considered.

What Does a Correlation Coefficient Tell Us?

McCall[13] says, "When the correlation is 0 to 0.4 it is low." Odell[14] states, "A coefficient of 0.30 to 0.40..... is high enough to indicate that there is a direct relationship between the two things correlated but at the same time it is so low that estimates of one of the traits from the other are scarcely better than mere guesses." Hull[15] puts it that a correlation "below 0.50 is practically useless for prognosis; from 0.50 to 0.60 possibly useful; 0.60 to 0.70 of genuine but limited value; 0.70 to 0.80 of decided value but scarcely ever found, and above 0.80 not obtained by present methods." He also makes the statement that, "It is doubtful whether a forecasting efficiency of less than about 13% ($r = 0.50$) will make the giving of tests worth while." Odell[6] says in still another form, "For a coefficient of 0.50 the ratio of the probable error of estimate to what it would be if the estimate were a pure guess is almost $^7/_8$; for a coefficient of 0.60 it is $^4/_5$ and even for one of 0.70 it is no more than $^7/_{10}$ of a pure guess."

From these statements and the values so far obtained for correlations between grades in high-school science and intelligence test ratings, such tests are of limited value in forecasting the outcomes of student endeavor in a given subject.

Both Jordan[8] and Gates[16] in almost the same language, advocate the "need of specific tests for native aptitude for each subject."

Do "Specific Tests" Indicate Aptitude for High-School Chemistry?

Jordan[5] found for 47 cases a much better correlation, 0.676, between part five of the Otis test and success in mathematics than 0.281, the correlation between ratings on the whole test and mathematics. Rogers[17] has a test of "mathematical ability" which is said to give correlations of from 0.60 to 0.90 with school marks. Hurd[10] gets a correlation of 0.865 between first and second semester grades for 91 physics students. These reports encourage one to look hopefully to such types of tests as aids in determining the aptitude of students for high-school chemistry.

The Bureau of Educational Research and Service of the University of Iowa generously placed at the disposal of the teachers coöperating in

[13] "How to Measure Education," pp. 392–3, The Macmillan Co., New York, 1922.

[14] "The Interpretation of the Probable Error and the Coefficient of Correlation," *Bull.* **32,** p. 47, University of Illinois (1926).

[15] *J. Educ. Research,* **15,** 327–8 (1927).

[16] *J. Educ. Psychol.,* **13,** 285 (1922).

[17] Buckingham, *Sch. Sci. & Math.,* **21,** 205–15 (1921).

this study, copies of their Form *A*, Iowa Chemistry Aptitude Test. These tests were given by the coöperating teachers to their chemistry pupils within the first few weeks of the school year 1927–1928.

This test was originally constructed for use with college freshmen.[18] However, since it presupposes no previous knowledge of chemistry there was no reason why it should not be used with high-school students for the same purpose as it had been used with college students.

For 284 of the high-school chemistry students in this study, the correlation of the Form *A*, Iowa Chemistry Aptitude ratings with the mid-semester high-school chemistry grades was found to be 0.44, with a probable error of 0.030. This value is not as high as that for the tenth-year science but is comparable with that, 0.44, found[19] between the ratings on this test and college chemistry students' first semester's grades. The correlation between the Aptitude ratings and the high-school full semester's chemistry grades was found to be 0.48 for 256 students, with a probable error of 0.033. This Aptitude Test in this case seems a better index of ultimate than of immediate success in the subject.

These results from the use of the Aptitude Test were rather disappointing to the teachers using them. Judging from results obtained by Rogers, Jordan, and Hurd, it was anticipated that a special test for chemical aptitude would at least show a more decided correlation with the chemistry grades than intelligence tests or grades in previous high-school work. This did not prove to be so.

However, these Aptitude ratings were used and were helpful. This may be made more evident by a different form of comparison. Considering all of the 256 students who remained through the semester, 80 were those placed in the upper quartile by the test with scores above 60, and 64 were those placed in the lower quartile by scores below 39. The success of these students, in terms of their semester's grade in chemistry, is shown in the following table:

TABLE I

	Per cent of students			
Semester chemistry grade:	Below 75	75–80	80–90	90—above
Students with Aptitude score:				
61 or above (upper quartile)	2*	21	24	53
39 to 61 (middle half)	7	30	36	27
39 or below (lower quartile)	27	39	27	7

* This means 2% of all students receiving an Aptitude rating of 61 or above had semester chemistry grades below 75%, etc.

It should be noted that the lower quartile group contained 40% of

[18] Cornog and Stoddard, THIS JOURNAL, **3**, 1409–10 (1926).

[19] Cornog and Stoddard, *Ibid.*, **2**, 704 (1925).

all the students who received 75% or below for the semester, the upper quartile group had 53% of all students receiving 90% or more in the course. Here it is noticeable that, as Guiler[20] remarks, "Tests predict achievement much better for students in the first and last intelligence quarters than they do for students in the middle quarters." It is also noticeable that the forecast for the superior student is here even more certain than for the slow student.

It has been found that a combination of two sets of data for a student[21] gives a surer index of his future performance than either one alone. The same principle is evident in the following tabulation showing the success, measured in semester chemistry grades, of students in the three quality groups into which their teachers had placed them. This placement was prompted by a composite of previous school records, the Aptitude Test grade, and the teacher's personal estimate of the pupil.

TABLE II

	Per cent of students			
Semester chemistry grades	Below 75	75–80	80–90	90—above
Superior	0	8*	20	72
Medium	12	28	33	27
Slow	37	43	20	0

* This says 8% of all students placed in the superior section by their teachers received semester chemistry grades between 75–80, etc.

How May We Find the Superior Chemistry Student?

In summary, correlations between previous school grades and high-school chemistry grades have been found as follows:

High-school chemistry and college chemistry[7] above 0.50.
Ninth-year algebra and high-school chemistry above 0.35.
Tenth-year science and high-school chemistry above 0.50.

Correlations between intelligence ratings and science have been cited for:

Otis and general science	0.50
Millers and general science	0.49
Alpha Army and general science	0.60
Terman and general science	0.64 each for 32 cases
A composite of Miller and Otis with high-school physics	0.76[8] for 91 cases[10]
Alpha Army and college chemistry	0.56 for 293 cases

Tests for special aptitude have been studied and correlation values are:

Mathematics and Part V of Otis has a correlation of 0.68 for 47 cases;[8]
Rogers mathematical aptitude test and grades in mathematics 0.60 to 0.90;

[20] *J. Educ. Research*, **16**, 365–374 (1927).
[21] Cornog and Stoddard, THIS JOURNAL, **3**, 1410 (1926).

First semester high-school physics with second semester high-school physics 0.87 for 91 cases;[10] and

Iowa Chemistry Aptitude with first semester high-school chemistry, 0.48 for 356 cases.

From this summary one is inclined to be cautious in making statements regarding the place of tests in the sectioning of students—especially if this sectioning accomplished by the tests is to alter the student's life plans. However, it is not too much to say: in classifying our chemistry students, intelligence and aptitude tests may help but with them "emotional and volitional traits[11,13] should be considered as well as the student's educational achievement found recorded in the form of school grades or often obtainable in personal estimates from former teachers."

A very heartening fact coming out of these studies is—tests do locate the superior student with more certainty than they do his less capable classmates. Once located, it is possible for his teacher to make special efforts to secure an achievement from him commensurate with his ability.

WOODEN SPLINTS FOR TESTING GASES

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Splints such as are commonly used in the elementary chemical laboratory to test for oxygen, etc., may be purchased in the form of applicators which are used by physicians for swabbing. The size is convenient, the cost is low, and the splints glow freely.

Standard applicators measure about 15 cm. in length and 1.5 mm. in diameter. They may be purchased through local hospitals at a cost, in quantity, of approximately 5 cents per hundred. At Syracuse University the cost averages 2 cents per student per year.

Coal from Crude Oil Refining By-Product. An oil refining plant that makes bituminous coal from crude oil and sells it at a profit was described recently by Prof. Walter F. Rittman of the Carnegie Institute of Technology speaking before the Second International Conference on Bituminous Coal at Pittsburgh.

In connection with the cracking process used to convert a larger portion of the crude oil into gasoline, a heavy refuse fuel oil was obtained. In treating the refuse oil there was produced an amorphous bituminous coal suitable for coking, burning under boilers, or even conversion into petroleum again by the liquefaction of coal processes now being developed abroad.

Prof. Rittman predicted that natural gas piped thousands of miles from the Texas fields to middle western cities would, during the next few years, compete seriously in price with fuel oil.—*Science Service*

ANOTHER METHOD OF PRESENTING FIRST-YEAR COLLEGE CHEMISTRY

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So much has been written and said about the difficulties of presenting a first-year college course in chemistry which will meet the needs both of the students who have and have not had chemistry in high school, that one hesitates to write on the subject. Many of the plans which are presented work well in large schools where students can be assigned to sections according to their ability and previous training. Many schools do have a different course for those who have entered college with a previous training in chemistry. Some of the larger schools can section the students according to their abilities. The first plan is not entirely satisfactory and the second is not practical in a small school where there are less than 150 students electing beginning chemistry. On account of schedule difficulties, it is almost impossible to change the recitation period of a student after school has started. Previous records and intelligence tests alone are not infallible indications of what a student will do in chemistry.

Most of the plans discussed in the literature are concerned with the first-year college course only. As far as I have been able to learn no college makes any distinction among their students after they have completed one year of college chemistry. Those who have had one year of college chemistry are supposed to be as well fitted for second-year chemistry as those who have had one year of college chemistry plus one year of high-school chemistry. Now if one year of college chemistry prepares a student for second-year college chemistry and if high-school chemistry is worth anything at all, why should a student who has had a good course in high school put in a full year in college in preparation for the second-year chemistry course? It does not seem consistent to attempt to give the student credit for high-school chemistry at the beginning of the first year of college chemistry but not at the end of the year. This is the case if at the end of the year he has the same standing as the student who has had no high-school chemistry.

In the past we have had two courses in inorganic chemistry, one for those students who have had chemistry in high school, and one for those who have not. It has been our experience, however, that there is just as much difference between the good and the poor students within either course as there is between the students of the two courses. Some students were well equipped while others had but little idea of the meaning of chemistry.

Last year all the students who had signed up for beginning chemistry were scheduled in one course regardless of whether they had or had not had high-school chemistry. It was soon apparent, as was expected, that

there were certain outstanding students who really knew the subject matter that had to be presented to the class as a whole. It is not very inspiring for a student to have to listen to facts with which he is quite familiar. At the end of the first six weeks those students were selected who had a good course in high school and who were doing good work in the college course. They were given the option of taking a special course in chemistry; a course requiring much more work than the regular one.

No additional credit was offered, but the extra work was more nearly commensurate with the students' abilities, such that at the end of the year they would be one semester ahead of the students who took the regular course. As evidence that good students will do extra work if shown that the results will be beneficial, all thirteen students selected, representing eleven different high schools, were anxious to take up the special work outlined.

These special students continued their classroom work with the other students for the rest of the first semester. Instead of the regular laboratory work they were given the elementary qualitative analysis that is ordinarily given the regular students during the second semester. In addition to the different laboratory work, quite informal lectures were given to these students by the head of the department at least twice a week on such topics as gas laws, valence, equivalents, solubility, ionization, solubility-product, precipitation, neutralization, mass action, common ion, normality, oxidation-reduction, etc. Attendance was not required at these special lectures, but the students attended. It was also understood that the students were to feel free to go to the head of the department at any time for information or advice. In this way a better personal contact was established. It was agreed that if the student did not do good work during the first semester he would have to go back with the regular group at the beginning of the second semester.

At the beginning of the second semester these thirteen students, the total number selected, entered quantitative analysis along with twenty-seven other students who had had one full year of inorganic chemistry in college, one semester of advanced qualitative analysis and many of them high-school chemistry in addition. Next year these students will take advanced qualitative analysis during the first semester and another semester of quantitative analysis during the second semester.

The students' grades for this course are rather interesting. Numerous short written tests based either on the advanced assignments or on some work that had already been discussed in class were given. The grades given are based on these written quizzes and semester examinations. In this class of forty, four students received "A," fourteen "B," sixteen "C," four "D," and two "I." A "D" does not count toward a major in Wooster College. Three of the four "A's" went to these special students,

four of the fourteen "B's," and six of the sixteen "C's." Or putting it in another way: 23% of these special students made "A," 31% "B," and 46% "C." In comparison with these: 4% of the other students made "A," 36% "B," 35% "C," and 15% "D."

Of course, it is well known that one year is not enough to prove anything, and next year's results may be quite different. The students under discussion, however, realized that much was expected of them and they attempted to show themselves worthy. If, in addition to having the subject matter presented interestingly, the students can be made to realize that nothing less than their best work will be acceptable, good results are inevitable.

Regardless of what may happen another year, the following results seem to have justified this experiment during the past year at Wooster. (1) It aroused and maintained the interest and enthusiasm of the student. (2) It served as a challenge to the student to do his best. (3) It gave more personal contact between student and teacher. (4) It gave the student work commensurate with his ability. (5) It put the good student with a group of other good students. (6) It gave the student one semester of advanced standing. (7) It will enable the student to include an additional semester of advanced chemistry in his major.

EXHIBIT OF HIGH-SCHOOL STUDENTS' WORK IN CHEMISTRY

An exhibit of students' work in chemistry in high schools is being planned for the spring meeting of the Division of Chemical Education at Columbus, Ohio. All teachers of high-school chemistry are invited to prepare and send in exhibits of their work. Any inquiries regarding the exhibits should be referred to Dr. Wm. McPherson, Ohio State University, Columbus.

Looks to Chemists to Protect Health. Future advances in the science of immunity, which is the body's resistance to disease, will be made largely by chemists, either alone or in association with immunologists, predicted Dr. H. Gideon Wells of the University of Chicago at the recent Institute of Chemistry of the American Chemical Society.

"Immunity may be appropriately called the chemical warfare of existence," said Dr. Wells. "The disease germs attack and kill us by the poisons they produce. Our bodies are constantly producing poisons to defend themselves by killing the germs. Through chemistry we can gain knowledge of just what these mysterious protective agents are, how they act and how to produce them artificially. Then we shall not have to depend on the dilute solutions of these agents that we can extract from a horse or can cause to develop in man's own blood, such as our present serums and anti-toxins, but can give man as much as he needs of the active agent that has been prepared by synthetic chemistry."—*Science Service*

THE CHEMISTRY TRAINING OF HIGH-SCHOOL AND COLLEGE STUDENTS*

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During the past few years numerous publications have appeared describing the content and function of the Iowa Placement Examinations (see bibliography at the end of this paper). In this series of examinations are two chemistry tests designated, respectively, Chemistry Aptitude and Chemistry Training. Both examinations are ordinarily given to students who are beginning their course in college freshman chemistry, preferably at the first meeting of the course. The Aptitude Examination is given to students who did not have courses in chemistry previous to entering college, while the Training Examination is given to students who offer high-school chemistry for entrance credit. This paper treats only of the Training Test or Examination.

Since the publication of the Chemistry Training Examination by the Extension Division of the University of Iowa it has been used by large numbers of college and university teachers of freshman chemistry. The scores thus made have been found to have value not only for estimating the amount and character of the high-school chemistry subject matter possessed at the beginning of the freshman year in college, but also in forecasting the probable future success of individuals in the course. Perhaps teachers find the main value of the Training Test to be in the help it affords in the immediate sectioning of large classes into intellectually homogeneous groups. From the reports of college and university teachers who have thus used the Training Test the authors have compiled data which, in so far as the Training Test is a trustworthy guide, constitute fair norms of the effectiveness of current teaching of high-school chemistry. This material has been previously reported by the authors.[1]

In response to requests for a standardized examination that would survey freshman college chemistry similarly to the Training Test for high-school chemistry, the authors considered ways and means of devising such an examination. Contributory to this end, the Training Test, Form *A*, was given in May, 1927, to 474 college students who were just finishing their first course in chemistry in four midwestern state-supported institutions. These institutions, whose coöperation made this study possible, were University of Illinois, University of Iowa, Oklahoma Agricultural and Mechanical College, and Purdue University. Each has freshman chemistry classes numbering from 600 to 1200 students, so that the 474 students who took the Training Test represent

* Read before the Division of Chemical Education of the American Chemical Society at St. Louis, April 17, 1928.

[1] THIS JOURNAL, **2**, 701–8 (Aug., 1925), and **3**, 1408–15 (Dec., 1926).

a sampling from upward of 3000 students. The final semester grades made by these students were also supplied. This study, then, presents the three groups of data listed below.

First, a table of the scores made by a sampling of 583 students with only high-school training in chemistry who took the Training Test (Form *A*) at the *beginning* of their freshman year at the following institutions: Case School of Applied Science, University of Minnesota, Montana State College, Utah Agricultural College, and the University of Washington. These data are from the same source as those given in the previously mentioned studies of the authors. They are placed at the left in Table I.

Second, scores made on the Training Test in May, 1927, by the 474 students mentioned above who were just completing a year of freshman chemistry at the State Universities. These data are placed at the right in Table I.

Third, a table of the coefficients of correlation between Training Test scores and semester grades in chemistry at the universities which gave the tests after a year of college chemistry. These figures are in Table III.

The remainder of this paper deals with the following topics:

1. A comparison of the scores made by high-school and college students.
2. A comparison of the scores and final semester grades of college students.
3. A discussion of some of the implications of the findings.

A Comparison of the Scores Made by High-School and College Students

TABLE I[a]

	High-school students							College freshmen					
Scores (1)	*A* (2)	*B* (3)	*C* (4)	*D* (5)	*E* (6)	Total (7)	% (8)	*W* (9)	*X* (10)	*Y* (11)	*Z* (12)	Total (13)	% (14)
150–169	9	1	0	0	2	12	2.1	0	3	0	0	3	0.6
130–149	14	5	0	0	2	21	3.7	10	9	0	1	20	4.3
110–129	31	19	0	1	3	54	9.5	31	23	3	11	68	14.6
90–109	35	21	0	7	6	69	13.9	22	37	11	19	89	19.1
70–89	31	39	4	14	26	114	20.0	24	52	21	42	139	30.0
50–69	33	51	14	30	16	144	25.3	11	19	22	44	96	20.2
30–49	11	36	45	11	20	123	18.1	1	4	5	43	53	11.4
10–29	7	5	9	5	12	38	6.7	1	0	1	4	6	1.3
0–9	1	0	0	3	4	8	0.7	0	0	0	0	0	0.0
Number	172	177	72	71	91	583		100	147	63	164	474	

[a] The heading "High-School Students" refers to the 583 students who offered high-school chemistry for entrance credit and took the Chemistry Training Examination at the *beginning* of their freshman year in college.

The heading "College Freshmen" refers to the 474 students who took the Training Examination at the end of their course in Freshman chemistry.

The letters *A*, *B*, *C*, *D*, *E*, *W*, *X*, *Y*, and *Z* are for purposes of identification.

The outstanding facts of Table I are graphically pictured in Figure 1. The two graphs were made by plotting horizontally the median score in each of the score groups in column (1) of Table I. Thus the highest score group in column (1) is 150–169 and half way between these two numbers is 159.5, the value plotted at the extreme right of the horizontal line in Figure 1. The percentages of the entire high-school and freshman groups making scores within each of these score groups (Columns 8 and 14) are plotted vertically.

The curves in Figure 1 serve as a basis for the following observations:

1. The best scores made by college freshmen are virtually the same as the best scores made by high-school students; while the poorest scores

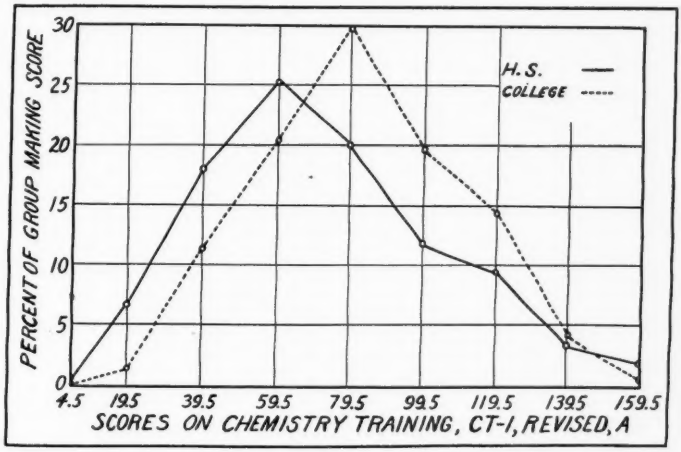

FIGURE 1

made by high-school students are but little less than the poorest scores made by freshmen.

2. The range and general distributions of scores are similar in both groups.

3. There is a real difference of performance in favor of the freshmen but its magnitude is not impressive.

4. The performance of the high-school group is especially noteworthy when it is recalled that the summer months had intervened between the time of finishing high-school chemistry and taking the Training Test.

In view of the similarity of the scores made by the two groups of students represented in Table I and also in Figure 1, a count was made of the right, wrong, and omitted answers to particular questions in the Training Test, with the purpose of gaining more detailed information

as to the kind of question generally answered correctly or otherwise. The results of these answer counts are recorded in Table II.

TABLE II

A COMPARISON OF THE NUMBERS OF RIGHT, WRONG, AND OMITTED ANSWERS TO PARTICULAR QUESTIONS MADE BY HIGH-SCHOOL STUDENTS AND COLLEGE FRESHMEN

				Percentage answering correctly	
				H.-S. students	College freshmen
Example 1. (True or False):					
Nitrogen is an active element				66.7	57.6
H.-S. students right	353;	wrong 149;	omitted 27		
Freshmen	273	193	8		
Example 2:					
Complete and balance KOH + HCl =				69.0	94.7
H.-S. students right	365;	wrong 44;	omitted 120		
Freshmen	449	17	8		
Example 3:					
Complete and balance $Al(OH)_3 + H_2SO_4 =$				19.3	46.8
H.-S. students right	89;	wrong 187;	omitted 253		
Freshmen	222	208	44		
Example 4:					
If 7 g. of iron unite with 4 g. of sulfur, how many g. of iron sulfide will be produced?				68.6	76.3
H.-S. students right	363;	wrong 57;	omitted 109		
Freshmen	362	46	66		
Example 5:					
The atomic weight of H is 1; of Cl, 35.5; of Zn, 65. What weight of Zn will be needed to generate 10 g. of H, using dilute HCl?				16.8	22.7
H.-S. students right	89;	wrong 114;	omitted 326		
Freshmen	108	127	239		

The authors are aware that the choice of questions included in Table II may be criticized as being insufficient in number, not representative of the objectives of instruction, and unfair to the students taking the test. Slocombe[2] observes that the omission of an answer to a question in an examination of this kind is not valid evidence that the student was ignorant of the answer. He contends that the student might have known the answer but did not have time to write it down. So far as it applies this observation is correct, but it is scarcely relevant to cases where the sum of the right and wrong answers exceeds the number of answers omitted. Another mitigating consideration lies in the fact that the students concerned took their chemistry course with one teacher or institution and were examined by another. So far as the content and method of the two situations differed, performance might be expected to suffer. When all such circumstances have been taken into account we doubt if many

[2] THIS JOURNAL, **4**, 894 (July, 1927).

chemistry teachers will view with satisfaction the data in Tables I and II. They will be inclined either to repudiate the whole matter as not sufficiently established or to ask how the situation can be improved.

A Comparison of Chemistry Training Examination Scores with Final Second Semester Grades

The extent to which the Chemistry Training Examination given in May predicted the final semester rating of the students in chemistry (as represented by semester grades) is given in Table III. It is clear that there is a substantial relationship between the content of the Training Examination as designed as a measure of high-school chemistry and the content of Freshman college chemistry as offered in these colleges. The average of the four coefficients is 0.64, but the extent to which such a figure really represents control of all the variables entering into semester grades is given by the value of $1-k$, where $k = \sqrt{1-r^2}$. Thus k (the *alienation*) here is 0.77 or 77% and our total factors controlled are $1-0.77$ or 23%.[3]

TABLE III

CORRELATION BETWEEN CHEMISTRY TRAINING EXAMINATION GIVEN IN MAY, 1927, AND FINAL SECOND SEMESTER GRADES IN CHEMISTRY

Institution	No. of cases	r	Type of semester grades used
University of Illinois[a]	100	0.56[b]	Examination scores (0–96)
University of Iowa	62	0.67	Letter grades (5)
Oklahoma Agric. & Mechan.	164	0.74	Letter grades (5)
Purdue University	147	0.59	Letter grades (5)

[a] Final examination vs. *CT*-1,*A* at Illinois.

[b] r = coefficient of correlation.

It should be recalled that the Chemistry Training Examination is given in a single class-hour (50 minutes). In order to discover the probable highest value which an examination could show as an estimate of semester grades the correlation was computed between the grades on the final examination (two hours in length and principally objective) and semester grades in chemistry for the group above at the University of Iowa. This proved to be: $r = 0.79$. Semester grades are, of course, partly dependent on final examination performance, and it appears that the only ways this figure of 0.79 could be raised would be to (*a*) give even greater weight to examination performance in making up semester grades, and (*b*) improve the reliability of semester grades by recognizing smaller differences among students. The 5-letter system is simply a rough approximation, and fails particularly with respect to the grade of *C*. It is

[3] See Kelley, T. L., "Statistical Method," The Macmillan Co., New York, 1923, p. 174.

possible that the especially high prediction obtained at Oklahoma was in part due to the severity of grading there—about 50 per cent of the students having received the lowest grade given (*F*) and these students at the same time centering about the low Training score of 50. At all events an examination of the placement type, while significant, does not have a majority rule in the determination of semester grades.

Discussion of Some Implications of the Findings

A few points which lie within the practical experience of the authors and are relevant to the findings reported above may be elaborated here.

First, we believe that the frequently expressed idea that "freshman instructors would prefer to teach chemistry to students who have never dabbled in the subject in high-school"[4] is not warranted on the basis of the grades these students make in the course. Possibly in small groups, freshmen with high-school entrance credit in the subject may appear to disadvantage, but not in large groups over a period of years. We submit that the poorer half of the class, both in high-school and college, never did know much chemistry and lacked the mental capacity ever to get real insight into what it was all about. So long as such students enrol in our classes, render themselves inconspicuous by never saying much, and allow the brilliance and understanding of the best students to deceive us as to the status of *general* class comprehension, their presence has not been an obvious burden. But poor students with high-school preparation in chemistry become singularly conspicuous. Is not the adverse opinion that many college teachers hold in regard to high-school chemistry caused by this noticeably poor performance of a few individuals rather than the statistically averaged performance of all students who had high-school chemistry?

Second, some colleges segregate students who have had high-school chemistry and give them separate instruction. Sometimes the content of this instruction is but an amplified echo of the instruction given students who never had chemistry previously. The arrangement is seldom entirely satisfactory for this reason: the poorer half of the class is as poor as ever and the better half knows beforehand most of the things offered in the courses. Consequently, the better students are polite but bored. As a possible alternative we suggest that at the beginning of the freshman year the students who have had high-school chemistry be given a suitable examination in elementary chemistry; that the poorer half be eliminated from the group either by excluding them from chemistry classes or by assigning them to the sections in beginning chemistry; and that finally the better half be given a course in chemistry which represents a real advance instead of a futile repetition. At the University of Iowa we

[4] Editorial, THIS JOURNAL, **5**, 6 (Jan., 1928).

have proceeded along these lines for several years and have found the method satisfactory. We *prefer* students who had high-school chemistry.

Third, we believe that the low attainment in the poorer half of both high-school and college freshman chemistry classes is not due entirely to the incompetency or inefficiency of the teachers concerned. Rather we believe that the mental limitations of these students is a factor that carries considerable weight. Unconsciously, what many teachers of freshmen complain of when they refer slightingly to high-school chemistry is not so much what the high schools failed to do as it is what the teacher individually is unable to do because of the mental limitations of the student. They unthinkingly blame the high school for the poor results, when, as a matter of fact, it is doubtful if any teacher under existing conditions could greatly improve upon what the high-school teachers have already done with the students of low native ability. Therein lies the importance of the rating afforded by a chemistry aptitude examination.

Fourth, there is the matter of the fallibility of grades. Normally, an inquiry of fallibility would include both Training Test scores and final grades. It would of necessity deal with the purposes and aims of instruction, for a measurement of progress is impossible without knowing the ultimate goal. The various efforts toward establishing uniformity in courses of study, as recorded in THIS JOURNAL from time to time, are evidence that "ultimate goals" are not very clearly defined. When objectives are understood, devices can be invented to measure accurately progress toward their attainment. As things are, we believe that many grades represent little beyond the ability to answer a series of questions for which students have been primed.

Fifth, in which direction is progress to be made? Those who are trying to define ultimate goals have concerned themselves chiefly with subject matter—which topics shall be included and which excluded. So far as we are aware this selection has been based mostly on questionnaire data and a majority vote of committees. These efforts are praiseworthy, and with the addition of trial and error are doubtless making for progress. But in this preparation of a diet for our chemical infants would it not be well to study their intellectual digestive capacities, as well as the composition of the diet? Would it not be worthwhile to learn the actual time required for representative groups of students to acquire 100 per cent knowledge (or 50 per cent, or x per cent) of each unit topic in the various schemes? Then enough unit pieces could be put together to properly use the time actually allotted to chemistry in any particular school.

Here the question, "What is a representative group of students?" is pertinent. Experienced teachers, whether or not they approve of tests,

know that aptitude varies so widely that some students can gain a better idea of a principle, such as the law of Le Chatelier, in a single hour than others are ever able to gain. These two need different programs of study, and it is futile to expect both to pursue the same. Here the placement examination idea is of use. The Iowa Placement Examinations are but imperfect attempts to materialize this idea, but even in their present state they have been found helpful. When other workers have improved and standardized more accurate measures of chemical aptitude and subject matter is chosen to meet definite student capacities, progress will be accelerated. In attempting an answer to the question, "In which direction is progress to be made?" we would say progress is to be made in making the individual student rather than subject matter the reference point in the teaching of elementary chemistry.

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Nobel Prize Winner Showed How to Prevent Typhus Fever. Prof. Charles Nicolle, to whom the Nobel Prize in medicine for 1928 has just been awarded in recognition of his work on typhus fever, made his first discoveries about the disease in 1909. At that time he was a surgeon in the French Army, stationed at Algiers. Now he is director of the Pasteur Institute of Tunis.—*Science Service*

THE PREDICTION OF THE FUTURE PERFORMANCE OF STUDENTS FROM THEIR PAST RECORDS*

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This paper constitutes a report on a part of the work which we are doing in studying the value of the Aptitude or Placement Examination and of semester grades in predicting the future performance of our students.

Our Freshman classes are conducted similarly to those in other institutions. In 1926–27, 879 students who had not had chemistry registered for General Chemistry. In the first week these students were given the Iowa Chemistry Aptitude Test, *CT*-1,*A*. From the results of this test the students were sectioned for quiz and laboratory into groups of twenty-five students. There was no sectioning in the two hours devoted to lecture, demonstrations, and tests. For laboratory and quiz the whole class was divided into six groups of 150 to 200 students, depending solely upon the afternoon the pupil took laboratory. This group was then subdivided according to the Aptitude Test or term grades into groups of twenty-five students each. Thus on one afternoon the best twenty-five students would be in one group, the next best in another, etc. The laboratory and quiz for any one group was under the same instructor. One important difficulty of this method lies in the fact that there are five or six best groups of twenty-five students each, where there should be only two or three (10% of class) of these groups.

This sectioning according to ability was carried out throughout the three terms. The score made in the first term was used as a basis for sectioning in the second term, and similarly the score in the second term was taken as the basis for the sectioning in the third.

The examinations given were largely of the objective type and graded by means of scores. The term grades in per cent were obtained from score grades. In each examination scores were plotted and a curve drawn to see how well the markings were distributed. During the latter part of the last term a group of 164 students took the Iowa Chemistry Training Examination. These examinations were scored in the Departments of Chemistry and Education of the University of Iowa.[1]

Of the 164 students discussed by Dr. Jacob Cornog, only 131 started in the fall and completed the work in a regular manner. It is the performance of these 131 students which we will discuss. We believe these

* Read before the Division of Chemical Education of the American Chemical Society at St. Louis, April 17, 1928.

[1] Cornog and Stoddard, "Chemistry Training of High-School and College Students," THIS JOURNAL, **6**, 85–92 (Jan., 1929).

131 to be representative of the four hundred students who completed the year's work in chemistry and who had had no chemistry in high-school. As regards schools, the 131 are divided as follows:

Home Economics	39
Education	37
Engineering	26
Arts and Sciences	22
Commerce	5
Agriculture	2

For units of comparison the students were divided on the basis of their scores into four groups, or quarters, equal in number. Thus, the best one-fourth of the students fall in the fourth quarter, the next one-fourth in excellence of performance in the third quarter, and the poorest in the first quarter.

It would be expected that (in general) a student who places in the fourth quarter in an examination or term grade should, if he performs consistently, place in the fourth quarter throughout his work. Thus, theoretically, it should be possible to predict future performance from scores made in past exercises. The results are set forth in the accompanying Tables I to VI, wherein the relative standing of the student in one term or test is used to predict his standing in the next term or another test. In columns two to five is shown the percentage of students who maintained their respective positions; or who advanced their standing to a higher quarter, indicated by a plus mark; or who lowered their standing to a lower quarter, indicated by a minus sign.

TABLE I

COMPARISON OF STUDENTS' STANDING IN 1ST TERM'S WORK WITH THAT IN IOWA APTITUDE TEST

Quarters in aptitude score	Quarters in 1st term scores 4 %	3 %	2 %	1 %
IV	46.5	−28.6	−21.4	− 3.6
III	+24.2	30.3	−30.3	−15.2
II	+14.7	+35.4	26.4	−23.6
I	+ 8.6	+11.8	+31.2	48.5

TABLE II

COMPARISON OF STUDENTS' STANDING IN 2ND TERM'S WORK WITH THAT IN THE 1ST TERM'S

Quarters in 1st term's work	Quarters in 2nd term's work 4 %	3 %	2 %	1 %
IV	67.0	−27.6	− 3.3	− 3.3
III	+31.4	28.6	−34.3	− 5.7
II	+ 8.6	+22.8	34.3	−34.3
I	+ 3.2	+22.6	+32.2	42.0

TABLE III

COMPARISON OF STUDENTS' STANDING IN 3RD TERM'S WORK WITH THAT OF 2ND TERM'S

Quarters in 2nd term's work	Quarters in 3rd term's work 4	3	2	1
	%	%	%	%
IV	77.0	− 8.6	−11.4	− 2.9
III	+25.6	38.4	−23.0	−12.8
II	+11.1	+33.3	36.2	−19.4
I	+ 0.0	+10.3	+27.6	62.1

TABLE IV

COMPARISON OF STUDENTS' STANDING IN AVERAGE YEARLY SCORE WITH THAT IN IOWA APTITUDE TEST

Quarters in aptitude test	Quarters in average yearly score 4	3	2	1
	%	%	%	%
IV	46.5	−21.4	32.1	0
III	+20.6	35.3	−29.4	−14.7
II	+14.7	+26.4	32.3	−26.4
I	+11.8	+11.8	+14.7	61.8

TABLE V

COMPARISON OF STUDENTS' STANDING IN IOWA CHEMISTRY TRAINING *CT*-1,*A* TEST WITH THAT IN APTITUDE TEST

Quarters in aptitude test	Quarters in Iowa Training test *CT*-1,*A* 4	3	2	1
	%	%	%	%
IV	53.5	−39.3	− 7.2	0
III	+26.4	38.3	−23.5	−11.8
II	+17.6	+20.3	32.4	−29.5
I	+ 8.6	+27.9	+28.6	40.0

TABLE VI

COMPARISON OF STUDENTS' STANDING IN IOWA CHEMISTRY TRAINING *CT*-1,*A* TEST WITH THAT IN YEARLY AVERAGE SCORE

Quarters in average score	Quarters in Iowa Training test *CT*-1,*A* 4	3	2	1
	%	%	%	%
IV	82.2	−17.8	0	0
III	+29.0	48.4	−16.1	− 6.5
II	+ 2.9	+40.0	48.6	− 8.6
I	0	+ 8.6	+25.7	65.7

For example, take Table I and reading from left to right, we find that of the students who placed in the upper one-fourth or quarter IV on the Aptitude Test, 46.5% likewise placed in the highest fourth in the term grades, 28.6% placed in the second highest quarter, 21.4% in the next, and 3.6% in the lowest quarter; of the students in the first or lowest quarter, 8.6% of these advanced their standing to the highest quarter,

11.8% to the second, 31.2% to the third, and 48.5% maintained their same lowly position.

If the percentage figures of these students who performed as predicted in the six comparisons as tabulated above are arranged as in Table VII,

TABLE VII

THE PERCENTAGE OF STUDENTS WHO PERFORMED AS PREDICTED

Comparison	Quarters 4	3	2	1
	%	%	%	%
Score 1st term from aptitude test	46.4	30.3	26.4	48.5
Score 2nd term from 1st term	67.0	28.6	34.3	42.0
Score 3rd term from 2nd term	77.0	38.4	36.2	62.1
Final aver. score from aptitude test	46.5	35.3	32.3	61.5
Training score from aptitude test	53.5	38.3	32.4	40.0
Training score from final aver. score	82.2	48.4	48.6	65.7

it is distinctly evident that only in the upper and lower quarters is there indication of any correlation, and it appears that one may predict with some accuracy the performance of the best and the poorest students;[2] but it is not possible to predict with any certainty how students of the two middle quarters will perform. Predictions from the Placement Examinations are perhaps poorest of all. One may predict rather successfully the performance in one term of chemistry from the score made in the preceding term.[3]

Another way of representing predictions is by means of correlation factor.[4] A high correlation factor indicates good prediction and a low

TABLE VIII

THE CORRELATION FACTORS FOR THE VARIOUS COMPARISONS

Scores compared	r
1st term with aptitude test	0.44
2nd term with 1st term	0.61
3rd term with 2nd term	0.65
Grand average with aptitude test	0.42
Training test with aptitude test	0.57
Training test with final average	0.79

correlation factor a poor prediction. In Table VIII is shown the correlation factors for the prediction in the six comparisons given above.

The high correlation of 0.79 between the Training Score and final average scores is to be expected, since they are in a way actual perform-

[2] Cornog and Bartow, "An Experience with the General Intelligence Test in Teaching Freshman Chemistry," *Ind. Eng. Chem.*, **15,** 301 (1923).

[3] M. G. Wolf, "Relation between the Degree of Intelligence and Success in the Study of Chemistry," THIS JOURNAL, **5,** 76–83 (Jan., 1928).

[4] Gilliland and Jordan, "Educational Measurements and the Classroom Teacher," The Century Co., **1925,** p. 255.

ance of the same kind and scored in the same manner. It is also gratifying to note the efficacy of the sorting and classifying effect of the three terms in the case of the best and poorest students.

From studying the data as given in the preceding tables, it will be noticed that in the middle half of students there is no definite trend as is shown in the upper and lower quarters. One must consider that in the upper and lower quarters students may move in only one direction, while in the case of the second and third there are two borders from which students may move into or out of the quarter. Also, the range of scores in these two quarters is smaller than that of the first and fourth.

A statistical study of the sigma differences might be valuable but, on the other hand, the student is actually placed and given a percentage or letter grade from his relative score, and regardless of the outcome, the instructor will judge him according to his score. To substantiate the above statement, the individual performance of the students was examined, and the following information obtained.

Of all the students tested, nine placed in the upper quarter in all tests, eight placed in the upper quarter in three tests, and eleven placed in the upper quarter in at least two tests, making a total of 84% which performed as predicted in one-half or more of their work. A similar condition existed in the case of the students in the lowest quarter, of which five placed poorest in all tests, thirteen placed poorest in three tests, and four placed poorest in two, making a total of 67% which performed as predicted in one-half or more of their work.

A different result was obtained with the middle half. Taking the third quarter only, two placed third in all tests, five placed third in three tests, and seventeen placed third in two, making a total of only 50% which performed as predicted in one-half or more of their work. The data likewise show that prediction is possible only with the best and poorest students.

In conclusion one may repeat the statement that it seems to be possible to predict the performance of the best and of the poorest students. Likewise, it would seem to be possible then to do much with these students through separating them from the others. It also appears doubtful whether any sectioning of the students of the second and third quarters would be profitable.

Farm Industry Book Printed on Cornstalk Paper. Paper made from cornstalks will be used in the printing of a book on farm products in industry soon to be issued. The author, Dr. George M. Rommel, agricultural expert, investigated the problem of waste materials in agriculture. As a demonstration of the use of one of the most plentiful of farm by-products he conceived the idea of printing his book on a new paper made from cornstalks which are usually wasted.—*Science Service*

A NEW METHOD OF MEASURING OSMOTIC PRESSURE[1]

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Recently there has been developed in the chemical laboratories of the Johns Hopkins University a new method of measuring osmotic pressure, applicable in many instances in which the previous methods could not be applied, and which greatly extends the possibilities of using this property as a means for studying the nature of solution.

The standard method for measuring osmotic pressure has made use of a porous clay cell which acted as a support for a semi-permeable membrane. This membrane permitted the passage of molecules of solvent and held back those of the solute. The difficulties in obtaining a satisfactory membrane are considerable, and only a membrane of cupric ferrocyanide has proved really practicable. This membrane has allowed measurements to be made over a considerable range of concentration on solutions in which the solvent molecules are large, such as solutions of sugar or phenol. However, it is not entirely impermeable to the ions of electrolytes and up to the present time it has not been possible to make direct osmotic pressure measurements on these solutions.

In a solution, the molecules of solvent may be considered as being diluted by the molecules of solute. If the solution be separated from some of the pure solvent by a membrane which permits the passage of solvent only, the molecules will diffuse through the membrane from a point of higher to a point of lower concentration, and the volume of the solution will increase until a hydrostatic pressure which just balances the diffusion tendency is built up on the solution side of the membrane. This increased pressure within the solution has been defined as the osmotic pressure of the solution.

It is seen that the increased pressure within the solution just balances the diffusion tendency of the solvent to flow through the membrane. Conceivably the diffusion tendency might as well be balanced by a tension placed on the pure solvent which would act to prevent it from entering the solution. It is evident that a tensile force of this character would numerically equal the osmotic pressure as defined above.

Principles Involved

The new method makes use of two general properties of liquids which are not ordinarily considered. The first is the change in vapor pressure with curvature of the surface; that is, a drop of liquid has a greater vapor pressure than a plane surface, and conversely, a concave surface has a

[1] The author is glad to acknowledge his association with Professors J. C. W. Frazer and W. A. Patrick in carrying out the experimental work which forms the basis of this article. This method described here also appears in the Remsen number of the *J. Am. Chem. Soc.*, **50**, 2958 (Nov., 1928).

somewhat lower vapor pressure. The other property is that, in the absence of excess quantities of dissolved gases, liquids will support a tension in virtue of the cohesion force between the molecules.

A solution of a non-volatile solute in a volatile solvent when in contact with the vapor phase exerts its vapor pressure. This is somewhat less than the vapor pressure of the pure solvent at the same temperature due to the presence of the non-volatile solute. If some of the pure solvent be brought into contact with the vapor space also, the liquid will vaporize from the pure solvent in consequence of its greater vapor pressure and the vapor will flow over and condense into the solution. In the case of a solution of potassium chloride and pure water at the same temperature each in contact with the same vapor space, water will vaporize and flow over and condense into the solution. It is seen that the vapor phase acts as a perfect semi-permeable membrane which permits the passage of solvent molecules, while the solute molecules are retained in the solution.

In the method worked out, the pure liquid water was located within the capillaries of a thin porous disk. Beneath the disk was a quantity of water and below this a column of mercury. By means of the mercury column it was possible to place a tension on the water. As indicated, the liquid would support this tension when the dissolved gases had been removed and when the surfaces were such as to be thoroughly wetted by the liquid. The result of this tension was to draw the water slightly into the capillaries of the porous disk, thereby changing the curvature of the surface. When a tension equal to the osmotic pressure of the solution was applied, the curvature of the surface was changed to such an extent that the vapor pressure of the pure water became equal to the vapor pressure of the solution.

In order to determine the equilibrium point, the rate of distillation from the porous disk to the solution was measured when less than the equilibrium tension was applied. The rate of distillation served as a measure of the tendency of the system to come to equilibrium. On increasing the tension on the liquid, the curvature of the surface was increased and the system brought closer to the equilibrium point. The rate of distillation then decreased correspondingly. On plotting several rates of distillation against the corresponding tension on cross-section paper, it was found a straight line resulted which could readily be extrapolated to the zero axis. This intercept gave the tension corresponding to zero distillation which is equal to the osmotic pressure of the solution.

Apparatus

The general arrangement of the apparatus is indicated in Figure 1. The solution was floated on mercury within a glass bulb of about 750 cc. capacity. The porous disk was fused into a pyrex funnel shown at *B*.

Beneath the disk was a supply of pure water extending down to the mercury column at C. Located at D was a small platinum paddle which was attached to a glass rod extending down the leg at E and rotated through a mercury seal at the bottom. The water distilled from the surface of B and over into the solution A. The rate of distillation could be readily followed by the movement of the mercury meniscus in a small tubing at C.

From C the mercury extended down through a small bulb with a side arm and then to an ordinary leveling bulb open to the atmosphere as indicated at F. This could be raised or lowered by means of a screw. The side arm from the bulb at H was connected with the vacuum pump and completely evacuated, so that the mercury extended the barometric height to G. The glass tubing at C and G was of the same diameter so that no correction for capillary effects was necessary.

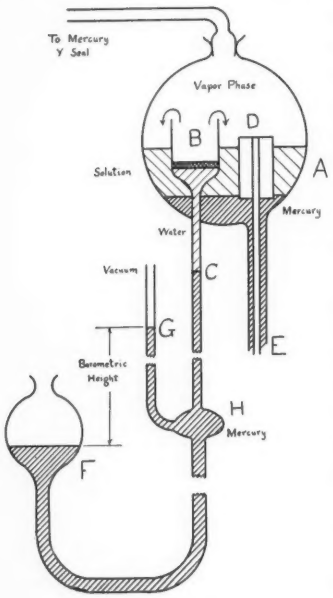


FIGURE 1

From a consideration of the figure it is seen that a pressure exists above the surface of the porous disk equal to the vapor pressure of the solution. This pressure is absent above G. Therefore if this amount be subtracted from the height at G a level is obtained such that the weight of mercury and water above this point is supported by the porous plate, and the water is placed in tension by this amount.

Several points of importance developed during the course of the investigation. The porous disk involved much experimentation. It has to be of sufficient porosity to permit the water to pass readily to the surface. On the other hand, the pores had to be small enough to support a capillary height of liquid greater than the tension applied. Moreover, it had to possess a certain mechanical strength and be composed of insoluble materials which would be thoroughly wetted by the water. The final disks were composed of equal parts of clay and fine Pyrex glass powder. The ingredients were thoroughly mixed together with a little water and the disk molded. After carefully drying they were heated in an electric furnace to about 800°C., which fused the glass particles but not the clay. After cooling and grinding to size they could be fused into Pyrex glass funnels. The disk used in making measurements was one inch in diameter and about

an eighth of an inch thick. The pores were tested and held over an atmosphere and a quarter showing no evidence of having reached their limit even at this point. As the rest of the apparatus was designed for measurements below about half an atmosphere this range was ample.

Temperature control was clearly recognized to be of primary importance. A 0.001*N* solution of potassium chloride has an osmotic pressure of about 37 mm., yet the vapor pressure lowering is only approximately 0.00074 mm. This same change in vapor pressure results from a drop in temperature of 0.00055° at 25°C. Since the method outlined depends on the difference in vapor pressure between solvent and solution, it is evident that any appreciable difference in temperature will be serious. For this reason the disk and solution were brought into as intimate contact as possible. The whole apparatus was immersed in a thermostat controlled by a toluene mercury regulator which held the temperature sufficiently constant so that no movement on the Beckman thermometer could be distinguished. The quantity of mercury within the bulb also served to help hold the temperature constant. While no direct evidence of the accuracy of the temperature control is available the consistency of the measurements indicate that a high degree of success was obtained. It is probable that errors due to temperature fluctuation do not correspond to greater than a millionth of a degree.

The high heat of evaporation unquestionably tended to cool the surface of the disk and to warm the solution. This heat had to be returned to the disk by conduction, and the small thermal head was largely responsible for the small rates of evaporation found.

Since it was planned to work with solutions of extreme dilution it was necessary to know the approximate "solubility" of Pyrex glass in water. This is probably the formation of sodium hydroxide by the action of water on the surface of the glass rather than any direct solubility. From measurements of the increase in conductivity, a figure of 0.000007 moles per liter, which is equivalent to an osmotic pressure of about 0.3 mm. was obtained. This is probably about the limit of accuracy attained in the measurements on the more dilute solutions.

Method of Procedure

The method of procedure was to redistill about 250 cc. of water from alkaline permanganate solution directly into a Pyrex flask. To this was added a weighed amount of purified potassium chloride, sufficient to give roughly the desired concentration after part had been evaporated. The solution was boiled for some minutes to remove as much of the dissolved air as possible and then cooled out of contact with the air. The system was then filled with water vapor and the solution allowed to flow up the leg *E* into the flask by introducing it through the mercury seal at the base. The

stirrer D was started and the vapor above the solution pulled off periodically by means of the vacuum pump. In this manner the air was slowly removed from the solution until less than 0.0001 mm. of air showed in the McLeod gage after a fifteen-minute interval. Usually a day was required to reduce the air to this figure.

As soon as the solution had become practically air-free, the mercury was lowered below the bulb H and a quantity of water distilled over, either from the solution or an auxiliary source, by cooling the apparatus at this point. All but the smallest trace of air had to be removed from beneath the disk or the liquid would not adhere. The last bit of air dissolved in the water and when once stuck, no further trouble was experienced. In fact, in order to make the liquid break away from the under side of the disk it

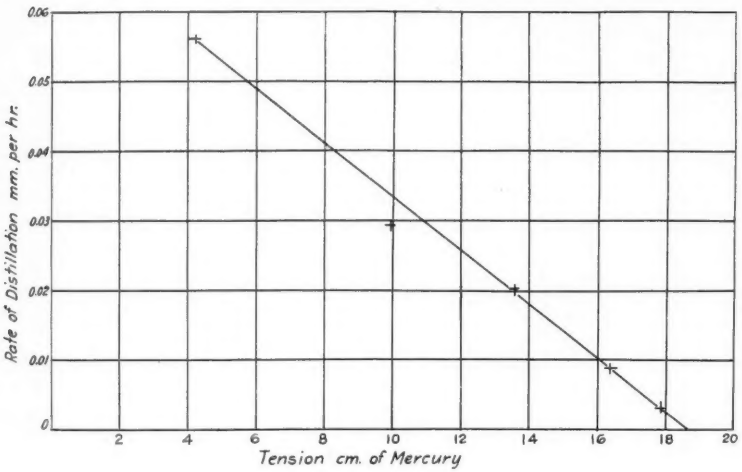


FIGURE 2

was necessary to force the water completely through the disk, when the mercury column could be broken in the larger part of the column.

As soon as the water had stuck, the desired tension was applied by means of the leveling bulb and readings could be started when the system had come to temperature, which generally required several hours.

An engraved metal scale with a cathetometer was used for measuring the various heights. The distillation was followed by observing the mercury level at C and plotting the readings at once to determine how soon constant conditions had been obtained. As soon as a satisfactory measurement of the rate had been made, a new tension was applied and another series of measurements started. By plotting a number of measurements of tension

against the rate of distillation, and extrapolating the curve to the zero axis, the equilibrium tension could be found.

The exact analysis of the solution was made after removal from the apparatus using the Zeiss interferometer, which had previously been calibrated against solutions of known concentration. In the case of the most dilute solution containing only 7.5 mg. of KCl per liter it was necessary to concentrate in a fused silica dish before analysis.

The tension was calculated by adding together the vapor pressure of the solution at the temperature in question, the mercury equivalent of a column of air-free water from C to the surface of the solution, and the reading at C. From this total was subtracted the zero reading at G.

Whenever the tension was closer to the equilibrium point than 4 or 5 mm., it was not possible to obtain good rates of distillation. The same held true if the total pull on the plate was reduced below about 5 mm. It was also not found possible to make measurements of back distillation; that is, from the solution to the plate. Probably this was due to the conditions of temperature prevailing.

The rate of distillation was probably as much dependent on the heat flow in the apparatus as directly on the difference in vapor pressure between the solution and solvent. However, the rate of heat flow will depend on the temperature difference between the various parts of the system and this in turn on the evaporation and condensation of the liquid. Consequently, in the last analysis, the rate will be indirectly dependent alone on the differences in vapor pressure as controlled by the concentration of the solution and the amount of tension on the plate. Zero distillation must represent temperature as well as pressure equilibrium.

This method of estimating the osmotic pressure is illustrated by the following table: KCl solution, temperature 24.85° C., original concentration 0.004 molal, final concentration (interferometer) 0.00539 molal.

Average tension (cm.)	Rate of distillation (mm./hr.)
4.208	0.560
9.950	0.293
13.548	0.201
16.347	0.088
17.852	0.030

Osmotic pressure (from graph) 18.60 cm.

Figure 2 shows the type of curve obtained when the rates of distillation from the disk are plotted against the tension of the water under the disk.

Four preliminary measurements were made on potassium chloride solutions at 25° C. using the method outlined. The solutions were all very dilute since this was the range for which the apparatus was designed and

it is this range also which possesses the greatest theoretical interest at the present time. The measurements are summarized below

Concentration (moles KCl per 1000 gr. of water)	Osmotic pressure (mm.)
0.00836	278.7
0.00539	186.0
0.00175	63.5
0.000474	17.5

The results obtained are in fair agreement with the values calculated from freezing-point determinations and the Debye-Hückel theory of complete dissociation.

Applications

The method of measuring osmotic pressure outlined may be applied along several lines which have not previously been possible. It is applicable generally to any non-volatile solute in a volatile solvent. As already indicated it can be applied to solutions of electrolytes and furnishes a means for investigating the activity of solutions at extreme dilution and for testing the recently advanced hypothesis of complete dissociation. It is possible to apply it to solutions of colloids, both lyophobic and lyophilic, which may throw much light on their character. Moreover, it can be used for other than water solutions; for example, solutions in organic solvents. In contrast to freezing-point lowering or boiling-point raising determinations, measurements may be made at any desired temperature.

It should also be pointed out that this method of measurement has the advantage of using air-free solutions. The solubility of air in water under atmospheric pressure is nearly 0.001 molal, which may well have an appreciable effect on the activity of the solute at low concentrations.

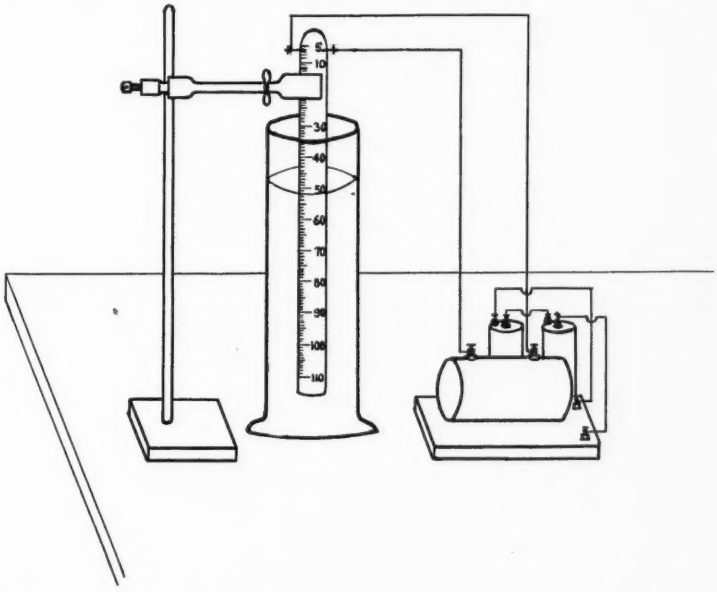
In a study of the properties of solutions it should be possible to attain reliable information at much greater dilutions through osmotic pressure measurements than through any other means, because of the much greater magnitude of this property. This is apparent if it is noted that for a 0.001 molal solution of a uni-univalent electrolyte the freezing-point lowering is approximately 0.0036° while the corresponding osmotic pressure is about 37 mm.

Ultra-Violet Light Used as Test for Dirt in Milk. A German scientist, Dr. F. M. Litterscheid, has recently found that valuable information can be gained by examining milks by ultra-violet light. In this way he can decide whether dirt in milk is due to external contamination or to the milk itself. When coated with Japan lacquer, the vegetable residues from cow's excreta give a bright red luminescence which serves to distinguish them from the ordinary milk residues (casein or albumin curd), for the latter are not affected by the lacquer. Dr. Litterscheid considers that his method will prove to be of great value in the routine examination of milk.—*Science Service*

A METHOD FOR THE QUANTITATIVE DETERMINATION OF OXYGEN IN THE ATMOSPHERE

GILES B. COOKE, UNIVERSITY OF MARYLAND, COLLEGE PARK, MARYLAND

A very satisfactory and accurate determination of the percentage of oxygen in the atmosphere can be made by employing a eudiometer. Two platinum wires are fused in the top of the eudiometer tube and allowed to project within the tube, with a small gap between their points. The wires are connected to a battery and induction coil, by which a spark is made to jump between the two platinum points. A definite volume of air is col-



lected in the eudiometer. The temperature of the water and the barometric pressure are recorded. It is convenient to have the eudiometer extend downward into a tall cylinder so that it can be adjusted to water level before readings are taken. The water should be drawn off into the cylinder and allowed to stand for several hours before the demonstration. The water and the air in the room will then be at the same temperature. Now a few cubic centimeters of hydrogen, more than is required to combine with the oxygen of the enclosed air, are slowly bubbled into the eudiometer. Adjustment to water level is made and the volume of the air plus the hydrogen is recorded. The gases are now exploded, the nitrogen acting as

a cushion. The eudiometer is lowered into the water for a few minutes so that the temperature of the residual gas may return to the temperature of the water. After adjusting the eudiometer to water level, the volume of the residual gas is recorded.

The loss in volume is due to formation of water by hydrogen and oxygen. One-third of the loss in volume is due to oxygen alone. By dividing the volume of oxygen by the volume of air, the percentage of oxygen is obtained. The following problem will show how the calculations are made.

Temperature of water (air)	18°C.
Barometer reading	752.4 mm.
Aqueous tension	15.4 mm.
Volume air	20 cc.
Corrected volume	18.2 cc.
Volume air + hydrogen	34 cc.
Corrected volume air + hydrogen	30.93
Volume residual gas	21.50
Corrected volume residual gas	19.55
Loss in volume (30.92−19.55) =	11.38
Loss in volume due to oxygen 11.38/3 =	3.79
Percentage of oxygen in air = 3.79/18.2 =	20.82

This method of determining the percentage of oxygen in the atmosphere is suitable to classes in general chemistry, whether high-school or college freshmen. The method possesses the following advantages:

1. Easy to carry out.
2. Easy for the student to understand.
3. Requires only a short time.
4. Gives accurate results.
5. Reviews the student on gas laws.

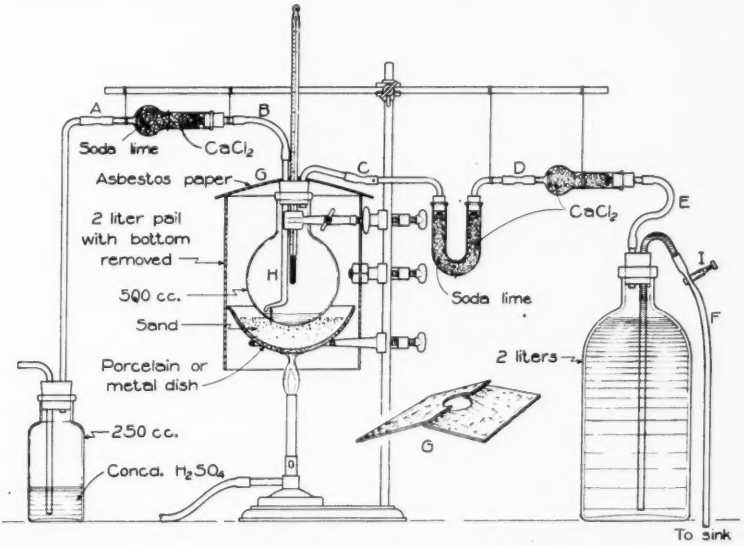
Russians Have Native Source for Camphor. A native source for camphor, important in both medicine and manufacturing, has been discovered in a species of wormwood that grows on the sandy steppes of the Government of Astrakhan. An oil extracted from this plant has been subjected to experiments at the Saratow experiment station, and was found to yield a good quality of camphor. The crystals differ in their physical properties from those of camphor obtained from camphor trees, but chemically they are identical with it.—*Science Service*

Shellfish Good Source for Growth Vitamin. The months with "R's" in them are good months to grow in, if the results of experiments by Dr. John Malcolm, New Zealand physiologist, reported to Nature, hold good generally. Dr. Malcolm has found, by test feedings to rats, that oysters are a good source for Vitamin *A*, which promotes normal growth. A native New Zealand bivalve, known as the Toheroa, is even better than the oyster, the experiments indicate. A Toheroa-canning industry is growing up, the product being sold as "Toheroa soup."—*Science Service*

THE VAPOR DENSITY OF STEAM*

C. S. MARTIN, STATE NORMAL SCHOOL, BOWLING GREEN, OHIO, AND J. E. DAY AND W. L. EVANS, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

For a number of years the Department of Chemistry of The Ohio State University has divided the students taking first-year chemistry into two major groups: *A*, those entering with one unit of high-school chemistry in the subject; *B*, those entering without such credit. During this period of time much attention has been given by those responsible for the instruction of these two groups of students to the matter of suitable laboratory work for those who have had the subject in high school. One of the proj-



ects assigned to the advanced class is that of studying quantitatively the experimental basis for the language of chemistry. One of our exercises consists in the experimental determination of the exact formula for water. This project involves not only the quantitative determination of hydrogen and oxygen, but also an accurate determination of the vapor density of steam. The work below is the result of much study on the part of the authors in the two institutions from which this communication has been sent to THIS JOURNAL.

In a previous paper two of us[1] described a method for the determination

* Read before the Division of Chemical Education of the American Chemical Society at the St. Louis Meeting, April 18, 1928.

[1] Evans, *et al.*, THIS JOURNAL, **1**, 152–3 (Sept., 1924).

of the vapor density of steam. The design and manipulation involved in the use of that apparatus presents certain inherent difficulties to the general chemistry student. With these points in mind we have several times rebuilt the apparatus retaining the original basic idea.

The present apparatus is arranged in accordance with the figure. The flask is kept out of immediate contact with the clamp by the insertion of two or three thicknesses of asbestos paper. Failure to do this may result in the condensation of water vapor back of the clamp, which is attended by a subsequent high value for the molecular weight of the steam. All stoppers are preferably of the rubber variety. The connectors *A*, *B*, *C*, and *D* are of pure gum rubber tubing; *E* and *F* are of any common type of rubber tubing. It should be noted in particular that the lower end of the glass tube, *H*, is drawn out to a capillary, bent and sealed as shown. A light file scratch is then made on the under side of the tube at the point indicated by the arrow. About 10 cc. of water are introduced into the flask and the train tested for air-tightness by opening the screw-clamp, *I*.

The clamp is then closed and the U-tube with the connectors *C* and *D* is removed, plugged, and weighed at a convenient time. The temperature is raised to between 135–140°C. and kept there. Any water condensing in the outer end of the outlet tube may be removed by means of a filter paper. When all of the water in the flask is evaporated, that condensed in the side-arm is also vaporized by means of a small flame.

The siphon is started by opening the screw clamp, the weighed U-Tube re-inserted in the train and the temperature immediately recorded. The glass tube *H* is then forced downward against the nearest wall of the flask until the tip is broken. The accomplishment of the latter is easily determined by the resumation of air bubbles through the sulfuric acid wash bottle. Twenty to thirty minutes are required for the sweeping of the vapor into the U-tube if the siphon is operated at the rate of two to three bubbles of air per second.

The U-tube is disconnected, plugged, and reweighed, the gain representing the weight of the known volume of steam.

Helium Leaks through Glass. Glass, which about fits the average man's idea of something absolutely leak-proof unless it is cracked, isn't so tight after all. It will permit a slow leak of the valuable gas helium, even when the high-quality pyrex variety is used, according to results of an experiment by Prof. G. P. Baxter, Dr. H. W. Starkweather and Dr. R. B. Ellestad of Harvard University, which will be reported in an early issue of *Science*. The three experimenters sealed up 1044 milliliters—something over a quart—of helium in a pyrex glass globe and left it there for over a year, weighing it carefully at intervals. At the end of 366 days it had lost 10.7 milliliters, or over one per cent of its original content, by slow seepage through the glass.—*Science Service*

POSITIONS OPEN IN VARIOUS COLLEGES AND UNIVERSITIES TO GRADUATE STUDENTS MAJORING IN CHEMISTRY

COMPILED BY WM. MCPHERSON, THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

Below are listed various Fellowships, Scholarships and Part-Time Assistantships open to graduate students majoring in chemistry in different colleges and universities for the academic year 1929–30. It is possible here only to give a very brief statement concerning these positions. Further details as well as application blanks may be obtained from the persons designated or in case no one is mentioned, by writing directly to the Departments of Chemistry in the colleges and universities listed. In general it may be stated that candidates for these positions must file their applications not later than March 1, 1929. The colleges and universities are listed in alphabetical order.

Brown University, Providence, R. I.—10 University Fellowships ($550–1000); 10 Scholarships (stipend covering tuition). Holders of Fellowships, who report for duty on August 1st, are not required to pay tuition. Address inquiries to Charles A. Kraus.

California Institute of Technology, Pasadena, Calif.—4 Graduate Assistantships ($750); 6 Teaching Fellowships ($900); 1 du Pont Fellowship ($750). The tuition ($180) must be paid until the holder has been accepted as a candidate for the Ph.D. degree, then half tuition ($90) must be paid. Address inquiries to R. C. Tolman.

Carnegie Institute of Technology, Pittsburgh, Penna.—Several Coöperative Fellowships with the Pittsburgh Station of the United States Bureau of Mines ($750). Address inquiries to J. H. James.

Clemson Agricultural College, Clemson College, S. C.—1 Fellowship ($500). This is a part-time Fellowship and the holder would be able to obtain his Master's degree in two years. Address inquiries to R. N. Brackett.

Columbia University, New York City.—Various University Fellowships, Scholarships, and Research Assistantships (varying from $500 to $1800). Address inquiries to H. C. Sherman.

Cornell University, Ithaca, N. Y.—3 University Fellowships ($400–750 and exemption from tuition and laboratory fees); 46 Assistantships ($500–675 and exemption from fees); 1 University Scholarship ($200 and exemption from fees). Address inquiries to L. N. Dennis.

Duke University, Durham, N. C.—Several Fellowships, Scholarships, and Assistantships. Address inquiries to R. N. Wilson.

The George Washington University, Washington, D. C.—4 Teaching Fellowships. Address inquiries to Colin M. Mackall.

Harvard University, Cambridge, Mass.—Several University Fellowships ($400–750). Address inquiries to L. S. Mayo, Secretary of the Graduate School of Arts and Science; a number of half-time Laboratory Assistantships ($850). Holders of such positions must pay a tuition fee of $200 besides fees for breakage and certain materials. Address inquiries to Gregory P. Baxter, Coolidge Laboratory.

Indiana University, Bloomington, Ind.—Special Fellowships ($1000–1200), minimum requirement, Ph.D. degree or equivalent; 1 Fellowship ($600); several part-time Assistantships ($400–800); 1 Grasselli Chemical Company Fellowship ($350). Address inquiries to R. E. Lyons.

Iowa State College, Ames, Iowa.—2 Scholarships ($270); 3 Fellowships ($540); 15 Graduate Assistantships ($700). Address inquiries to W. F. Coover.

Kansas State Agricultural College, Manhattan, Kans.—Several Graduate Assistantships (at approximately $500). Address inquiries to H. H. King.

Lafayette College, Easton, Penna.—2 Research Fellowships ($500 and $750); 1 Research Associate ($2500)—for the study of problems concerning the fundamental nature of viscous and plastic flow; 1 Research Associate ($2500–3500)—for investigation of problems connected with plasticity, elasticity, and fluidity. Address all inquiries to Eugene C. Bingham.

Lehigh University, Bethlehem, Penna.—New Jersey Zinc Co. Research Fellowship ($600), Archer-Daniels-Midland Co. and Wm. O. Goodrich Co.—4 Fellowships ($900) for research in linseed and other drying oils, and R. K. Laros Silk Co. Research Fellowship ($800): two-year appointment for all. H. N. Byllesby Research Fellowship ($750) and Columbian Carbon Research Fellowship ($1000): both carry exemption from laboratory and other university fees. 2 Student Research Fellowships ($750): open only to Lehigh University graduates. Address inquiries to H. M. Ullmann.

Louisiana State University, Baton Rouge, La.—5 Fellowships ($360), 8 hours of laboratory supervision required; 1 Assistantship ($600), 12 hours of laboratory supervision required; 3 Assistantships ($900), 16 hours of laboratory supervision required. Fellows and Assistants are exempt from tuition and certain University fees. Address inquiries to Charles E. Coates.

Massachusetts Agricultural College, Amherst, Mass.—4 Graduate Assistantships ($60 per month), one-half time assisting in laboratory courses required. All fees remitted. Address inquiries to Joseph S. Chamberlain.

Massachusetts Institute of Technology, Cambridge, Mass.—Several part-time Assistantships, usually appointed from resident graduate students.

Michigan State College, East Lansing, Mich.—3 half-time Graduate Assistantships, one each in electro, organic, and metallurgy ($800). Address inquiries to Arthur J. Clark, Kedzie Chemical Laboratory.

New York University, New York City, at *University Heights* (*Nichols Laboratory*).—Several Junior Teaching Fellowships ($600 with exemption from fees for three graduate courses); several Senior Teaching Fellowships ($800 with similar exemption). About six new appointments yearly. Address inquiries to Arthur E. Hill.

At *Washington Square College*.—Several Junior Teaching Fellowships ($600 with exemption as above); several Senior Teaching Fellowships ($800 with exemption as above); about fifteen new appointments yearly. Address inquiries to W. C. MacTavish.

Northwestern University, Evanston, Ill.—12 Graduate Assistantships ($800–1200); 21 Research Fellowships at ($500–1500); graduate tuition depends upon the number of semester hours of credit carried but does not exceed $150 per year in any case; Research Fellows are exempted from one-half graduate tuition, research chemicals are supplied, charges made for breakage. Address inquiries to Frank C. Whitmore.

Oberlin College, Oberlin, Ohio.—1 Grasselli Chemical Company Fellowship ($500 and exemption from tuition and fees); several Oberlin College Fellowships ($500 and similar exemption); 2 Graduate Assistantships ($750 with similar exemption); 2 Scholarships calling for freedom from tuition and fees. Address inquiries to Harry N. Holmes.

The Ohio State University, Columbus, Ohio.—13 part-time Assistantships ($1000); 30 Graduate Assistantships ($500); address inquiries to W. L. Evans. 1 Special Fellowship ($750); a number of University Scholarships ($300) and University Fellowships ($500), are also open to students in chemistry. All of the above carry exemption from fees (except matriculation of $10.00) and cost of chemicals. Address inquiries concerning Fellowships and Scholarships to William McPherson.

Oklahoma Agricultural and Mechanical College, Stillwater, Okla.—5 Graduate Assistantships ($500 the first year and $600 the second year with exemption from tuition and chemical fees). Address inquiries to O. M. Smith.

Pennsylvania State College, State College, Penna.—5 Graduate Assistantships ($800 and exemption from tuition and laboratory fees); 5 to 10 Graduate Scholarships which carry exemption from tuition and laboratory fees. Address inquiries to G. C. Chandlee.

Princeton University, Princeton, N. J.—13 part-time Assistantships ($650); 4 full-time Fellowships ($600–1000). Address inquiries to N. H. Furman.

Purdue University, Lafayette, Ind.—6 Teaching Fellowships ($800 plus laboratory fees and breakage). Preference given to men with Master's degree or at least one year of graduate work. Address inquiries to R. B. Moore.

Rice Institute, Houston, Texas.—6 Graduate Fellowships ($750 and exemption from all fees); six hours of laboratory teaching per week required. Address inquiries to Harry B. Weiser.

Rutgers University, New Brunswick, N. J.—5 or 6 full-time Assistantships ($1000). Address inquiries to R. G. Wright.

Stanford University, Stanford, Calif.—A number of Fellowships ($750); and Graduate Scholarships ($200); 3 Teaching Fellowships ($750); and a number of Teaching Assistantships (varying in compensation according to the service rendered). Address inquiries to Robert E. Swain.

The State College of Washington, Pullman, Wash.—4 Teaching Fellowships, requiring 12 to 15 hours per week assisting in the laboratory ($700 first year, $800 the second year), fees nominal. Address inquiries to C. C. Todd.

State University of Iowa, Iowa City, Ia.—6 Scholarships ($200–300); 4 Fellowships ($300–800); 3 Research Assistantships ($600 or more); about 15 Graduate Assistantships ($350); and 16 Assistantships ($700). Address inquiries to Edward Bartow.

Syracuse University, Syracuse, N. Y.—16 Graduate Instructorships ($750–900 and freedom from all fees); a limited number of Fellowships ($500 and exemption from fees); and a limited number of Scholarships which carry exemption from fees. Address inquiries to R. S. Boehner.

Tufts College, Boston 57, Mass.—1 Fellowship ($1000 and exemption from tuition); several Graduate Assistantships ($300, free tuition and free use of apparatus and chemicals). Address inquiries to Frank W. Durkee.

Tulane University, New Orleans, La.—1 Part-time Instructorship ($1000); 2 Graduate Assistantships ($450); 1 Student Assistantship ($300). All of the above carry free tuition and the remission of laboratory fees. Address inquiries to H. W. Moseley.

University of Alabama, University, Ala.—3 Assistantships ($675); two pure research and one teaching and research. Address inquiries to Stewart J. Lloyd.

University of Akron, Akron, Ohio.—2 Fellowships in Rubber Chemistry ($1000 with exemption from tuition, fees and deposits). Nine hours a week required of the holder in laboratory supervision. Address inquiries to H. E. Simmons.

University of Arkansas, Fayetteville, Ark.—1 or more half-time Assistantships ($600) and 1 or more fourth-time Assistantships ($250). Address inquiries to Harrison Hale.

University of California, Berkeley, Calif.—20 Fellowships and Teaching Fellowships. (These positions net about $650 after all fees are paid.) Address inquiries to G. N. Lewis.

University of Chicago, Chicago, Ill.—5 Fellowships ($750–900); 5 Fellowships ($400–520); 2 Fellowships ($200–250); 1 Research Assistantship ($960); 1 Research Instructorship ($1800) open only to those holding a Ph.D. degree; 4 Assistantships

($810); 5 Assistantships ($510); 5 Junior Assistantships ($410). All students are required to pay the graduate tuition fees of $70 per quarter. This, however, is included in the stipends given above. Address inquiries to Julius Stieglitz.

University of Cincinnati, Cincinnati, Ohio.—1 Baldwin Fellowship ($500–750) according to qualifications and training of the applicant; 2 Fellowships ($500); 12 Scholarships (carry free tuition and laboratory fees only). Address inquiries to Louis T. More, Dean of the Graduate School. In addition to the above there are also eight to ten Graduate Assistantships ($600–750, with exemption from tuition and laboratory fees). Address inquiries concerning these Assistantships to H. Shipley Fry.

University of Colorado, Boulder, Colo.—9 half-time Instructorships ($800); 6 Assistantships ($600); 1 Assistantship ($400) in sanitary chemistry; 1 Assistantship ($300) in organic chemistry. Address inquiries to John B. Ekeley.

University of Delaware, Newark, Del.—1 du Pont Fellowship ($300). Address inquiries to A. S. Eastman.

University of Florida, Gainesville, Fla.—6 Fellowships ($500) with exemption from tuition fee; approximately 8 Student Assistantships. Address inquiries to Townes R. Leigh.

University of Illinois, Urbana, Ill.—About 15 Teaching Assistantships of two types, namely, half-time ($600) and quarter-time ($300). Address inquiries concerning Assistantships to Roger Adams. Approximately 4 Scholarships and 10 Fellowships will be open for next year. Address inquiries concerning these positions to Dean A. H. Daniels of the Graduate School.

University of Kansas, Lawrence, Kans.—11 Fellowships for graduates of Kansas colleges (1 to each college) ($400); 12 University Fellowships ($400); 11 part-time Graduate Assistantships ($400–1000). Address inquiries to H. P. Cady.

University of Louisville, Louisville, Ky.—1 Special Fellowship ($300) for students interested in industrial work; 1 Special Fellowship ($500) for students interested in nutritional work; 3 half-time Assistantships ($500) plus tuition. Address inquiries to A. W. Homberger.

University of Maine, Orono, Me.—2 Teaching Fellowships ($500); also some loan funds available after the student has been at the University for one semester. Address inquiries to C. A. Brautlecht.

University of Michigan, Ann Arbor, Mich.—14 Assistantships in general chemistry, 1 in analytical chemistry, 1 in organic chemistry ($800); 1 du Pont Fellowship ($750), 2 American Petroleum Institute Fellowships ($1200); 1 University Fellowship ($500–600); 1 Scholarship ($200–300). Address inquiries to Moses Gomberg.

University of Minnesota, Minneapolis, Minn.—1 du Pont Fellowship ($750); 1 Shevlin Fellowship ($500); 30 Teaching Assistantships ($750 or $650 without one year's previous experience as Assistant). Both laboratory and university fees are remitted to holders of these positions. Address inquiries to S. C. Lind.

University of Mississippi, University, Miss.—3 Fellowships ($300) and remission of all laboratory fees. Address inquiries to J. N. Swan.

University of Missouri, Columbia, Mo.—1 University Fellowship ($600); 1 University Scholarship ($300); 15 Graduate Assistantships ($600–700). Address inquiries to Herman Schlundt.

University of Nebraska, Lincoln, Neb.—Several Scholarships ($350–500); several Fellowships ($500–750). No tuition is required of scholars and fellows, and allowance is made for chemicals and breakage of apparatus. Address inquiries to F. W. Upson.

University of Nevada, Reno, Nev.—1 Teaching Fellowship ($600) and 1 Assistantship in Agricultural Experiment Station ($900–1200); 1 Research Fellowship ($750). Address inquiries to G. W. Sears.

University of North Carolina, Chapel Hill, N. C.—1 Instructorship ($1500); 3 Teaching Fellowships ($500); 5 Assistantships ($750); 4 Assistantships ($500); 1 Assistantship ($200); 1 Fellowship ($300). Address inquiries to James M. Bell.

University of Notre Dame, Notre Dame, Ind.—5 Assistantships carrying remission of tuition, laboratory fees and maintenance (board and room on the university campus); 2 Non-teaching Research Fellowships ($750); 2 Teaching Fellowships ($1000). Address inquiries to H. H. Wenzke.

University of Pennsylvania, Philadelphia, Penna.—Several University Scholarships ($200–1000); several Research Fellowships open only to holders of Ph.D. degree ($1500). Address inquiries to H. Lamar Crosby.

University of Pittsburgh, Pittsburgh, Penna.—10 Graduate Assistantships ($800 and exemption from tuition fees). Address inquiries to A. Silverman.

University of Tennessee, Knoxville, Tenn.—4 Teaching Fellowships ($500 and remission of all tuition fees except $25.00 which covers the student activity fee, health and library fees). Address inquiries to Charles O. Hill.

University of Texas, Austin, Texas.—25 Assistantships. Salary for Senior Assistants ($550); other Assistants ($725–1200). Address inquiries to H. L. Lochte.

University of Utah, Salt Lake City, Utah.—5 Teaching Fellowships ($500). These Fellowships do not carry exemption from fees, which amount to about $60.00 a year. Address inquiries to W. D. Bonner.

University of Vermont, Burlington, Vt.—2 Part-time Instructorships ($800 and exemption from tuition fees); a number of University Fellowships ($700–800 and exemption from tuition fees), are also open to students in chemistry. Address inquiries to G. H. Burrows.

University of Washington, Seattle, Wash.—18 Teaching Fellowships ($720). Address inquiries to George M. Smith.

University of Wisconsin, Madison, Wis.—2 University Fellowships ($750); 1 du Pont Fellowship ($750); 1 or 2 University Scholarships ($250); 1 Special Scholarship for women only ($300); 4 or 5 Private Research Assistantships ($600); 5 or 6 Senior Assistantships ($1000–1200); 10–15 Junior Assistantships ($600–800). Address inquiries to J. H. Mathews.

University of Wyoming, Laramie, Wyo.—2 Graduate Assistantships ($600). Address inquiries to P. T. Miller.

Vanderbilt University, Nashville, Tenn.—3 Fellowships ($500); no charge is made for breakage; 3 Scholarships ($300 and exemption from fees for breakage). Address inquiries to J. W. Breckenridge.

Virginia Polytechnic Institute, Blacksburg, Va.—2 or 3 Fellowships ($500). Address inquiries to J. W. Watson.

Washington University, St. Louis, Mo.—5 Assistantships ($750 with free tuition, laboratory fees, and allowance for breakage); 1 Industrial Fellowship ($750 with similar exemption from fees); several University Fellowships ($500), and Scholarships ($200 with similar exemption from fees), are open to graduate students in chemistry. Address inquiries to L. McMaster.

Washington and Jefferson College, Washington, Penna.—2 Fellowships ($600 first year, and $750 second year). Address inquiries to A. H. Wright.

Wesleyan University, Middletown, Conn.—From 4 to 6 half-time Assistantships ($600 first year, and $800 second year, plus exemption from tuition and charges for breakage). Address inquiries to G. Albert Hill.

West Virginia University, Morgantown, W. Va.—12 Graduate Assistantships ($650); 3 Graduate Fellowships (approximately $1000). Address inquiries to Friend E. Clark.

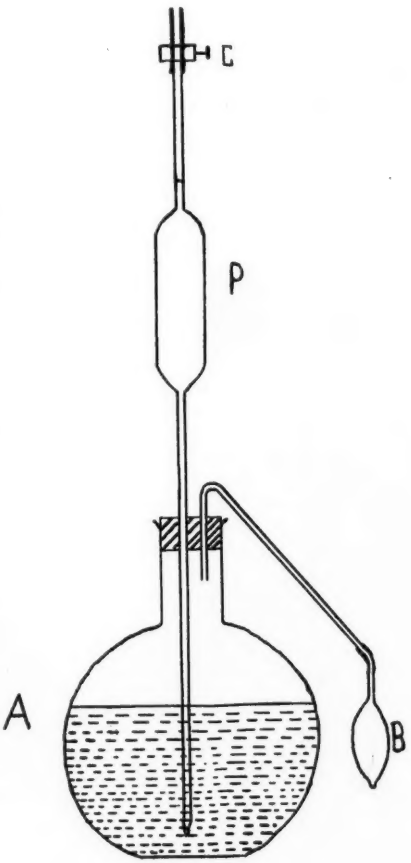
Western Reserve University, Cleveland, Ohio.—1 Cushman Fellowship ($750); 2 Ohio Chemical Manufacturing Company Fellowships ($900); 1 Scholarship ($500). All of these positions carry exemption from tuition and laboratory fees. 3 Assistantships ($200–1000 with free tuition in one graduate course) Address inquiries to O. F. Tower.

Yale University, New Haven, Conn.—Several laboratory Assistantships ($750, out of which tuition, laboratory fees and breakage amounting to about $250 must be paid); several Scholarships and Fellowships that are usually reserved for Ph.D. degree candidates in the final year; the Loomis Fellowship ($1500). Address inquiries to Arthur J. Hill.

SIMPLE DEVICE FOR PIPETTING OBNOXIOUS LIQUIDS

LEOPOLD SCHEFLAN, SYRACUSE UNIVERSITY, SYRACUSE, NEW YORK

The apparatus consists of a Florence flask A, a two-hole rubber stopper carrying a piece of glass tubing bent at an angle of about 45° to which an atomizer bulb B is attached, and the pipet P, which is fitted with a short piece of gum rubber tubing, and a screw clamp C.



To operate the device, slightly open the screw clamp and by lightly squeezing the bulb force the liquid into the pipet well above the graduation mark. Now close the screw clamp. Loosen the stopper from the flask to release the pressure and gradually drop the surface of the liquid in the pipet to the mark by carefully manipulating the screw.

This device may be used for (1) poisonous liquids, (2) solutions of volatile gases like NH_3, SO_2, etc., (3) large pipets which cannot be filled conveniently by suction.

TWELFTH CHEMICAL INDUSTRIES EXPOSITION ANNOUNCED

The Twelfth Exposition of Chemical Industries will be held at the Grand Central Palace, New York City, the week of May 6 to 11, 1929.

The Exposition draws together chemists, engineers, manufacturers, and others interested, from forty industries which are dependent in their operations upon a chemical change in the nature of the material or are under chemical control. These industries are:

Bleachers, Dye-Houses, and Textile Manufacturers; By-Products and Coke Ovens; Chemical Manufacturers; Engineers and Consultants; Fertilizer Manufacturers; Flavoring Extract, Fruit Juice, Syrup Manufacturers (Foods); Gas and Public Utilities Companies; Gas Mantle Manufacturers; Linoleum and Oil Cloth Manufacturers; Paint and Varnish Manufacturers, including Printing Ink; Paper and Pulp Manufacturers; Plastics; Powder Manufacturers (Explosives); Rayon (Artificial Silk) Manufacturers; Rubber Manufacturers; Schools, Colleges, and Technical Libraries; Soap Manufacturers (including Glycerin, Fats, Vegetable and Animal Oils, etc.); Storage and Dry Battery Manufacturers; Sugar Manufacturers and Refiners; Tanning Extract Manufacturers; Exporters and Importers; Glass and Ceramic Manufacturers; Government Departments and Laboratories; Metallurgical and Mining Industries; Petroleum Refiners; Cement, Lime, Gypsum, and Plaster; Tobacco Manufacturers; Chemical and Engineering Equipment; Publishers, Editors, Reporters; Students.

The Exposition of Chemical Industries has been a leader in the creation, development, and growth of the chemical industries of America. It brings together among its exhibits between 350 and 450 exhibitors displaying their products, which include the varied types like chemical engineering equipment and processes, and special machinery as used in the various industries. It embraces in this wide range of exhibits products like apparatus for precise measurement of pressure, volume, flow, temperature, time; laboratory apparatus, supplies, chemicals, etc.; the raw materials used in all the chemical industries, the chemicals, dyestuffs, technical materials, and chemical products which are applied in the industries and arts.

There are in the Exposition special sections for Laboratory Equipment, a Southern Section, and a Canadian Section, the latter two exhibiting the raw materials (minerals, agricultural, and forestry products) suitable for development and manufacture. In these special sections the communities located near or at the resources for which financial and industrial development is desired make headquarters, displaying maps and graphic charts showing why a factory should be located there to utilize their raw materials; railroad companies and State Governments are also among these exhibitors and in consequence of these exhibits in years past have brought to their localities plants which have created big industries and brought other related businesses.

Special consideration has been given to the methods of packing and shipping the products produced by the chemical industries. The firms which have devoted much research and expense along these lines will present their products in a special Section for Containers, Packaging, and Shipping Equipment.

One of the reasons for the tremendous production on such a large scale of the American industries is because the industries employ not large numbers of men but large numbers of machines. Hand labor for moving and transporting raw material, intermediate products, and the finished products is almost unknown. This work is done by machines which do all the conveying of gaseous, liquid, and solid material by means of air conveying, pneumatic conveying, or by fuel or electricity consuming machines for lateral or vertical conveying and transportation. In the great Chemical Industries Exposition exhibits of this nature will be displayed in a special Section for Materials Handling Equipment.

To reach the forty or more industries classified as the chemical industries there is no better market place—and this is the only one in America—than the Twelfth Exposition of Chemical Industries which will be held at the Grand Central Palace, New York City, from May 6 to 11, 1929.

The Students' Course of lectures which has been an institution in the past Expositions will be repeated again. These lectures by authorities in their work are divided into two groups: one for elementary students where an extensive knowledge has not been gained, and the other an advanced course for senior and graduate students. These courses have been well attended and many colleges give credit to the students for work done. This work is tabulated and graded at the Exposition by Dr. W. T. Read, Professor of Chemistry from Texas Technological College and a member of the Exposition Advisory Committee, who is in charge of the course.

Information concerning this Exposition may be obtained direct from the offices of the Exposition, in the Grand Central Palace, New York, Charles F. Roth, Manager.

Soap Dust Latest Explosion Hazard. Soap flakes and soap powders, being extremely explosive, take their place as the latest industrial hazard. Certain kinds of soap dusts when suspended in air are more violently explosible than most other industrial dusts, according to tests made at the Experiment Station of the U. S. Bureau of Mines at Pittsburgh. These soap dusts are easily ignited and explode violently, accompanied by much flame and large quantities of heat. This is in spite of the fact that soap is a compound of semi-organic nature and that sodium compounds in general have a cooling effect on the flames of explosives.—*Science Service*

The Chemistry Student

THE STRUCTURE OF MATTER. V. PRIMARY CELLS

OTTO REINMUTH, ASSOCIATE EDITOR

Last month, in connection with our discussion of ionization, we considered the phenomenon of electrolysis.[1] In other words, we noted how a solution of an electrolyte behaves when it is subjected to the action of an electric current of external origin. Let us now turn our attention to the manner in which electrolytic action can give rise to an electric current.

Solution

It will be necessary to begin with an apparent digression, for we must first examine briefly the phenomenon of solution. We know from experience and previous study that most solids have a certain tendency to dissolve in water. This tendency, for lack of a better name, has been called the solution pressure. Opposed to the solution tendency of the solid is the tendency of dissolved matter to pass out of solution; this is called the osmotic pressure. In the case of a salt and water, the solution is said to be saturated when the two opposing tendencies equal and balance each other. A saturated solution in the presence of excess solid salt is in a state of dynamic equilibrium—salt is passing into and out of solution at equal rates. This state of equilibrium may be reached from either side. Solid salt added to a supersaturated solution causes the crystallization of more salt until a state of equilibrium is reached. Solid salt added to an unsaturated solution dissolves until the solution becomes saturated.

If we consider a strip of metal[2] immersed in water, the case is somewhat similar, but there are very important differences. The metal, like the salt, has a certain tendency to go into solution but, unlike the salt, it is restricted in its manner of doing so. The salt may enter solution either in the form of its molecules or its ions. When it does either or both, the solution remains electrically neutral, for positive and negative ions go into solution in equal numbers. The metal, on the other hand, can enter the solution only in the form of positive metallic ions. Neither metallic molecules nor negative metallic ions go into solution. The result is that as soon as metal begins to go into solution, the metal plate becomes negatively charged from the excess electrons left behind, and begins to attract

[1] THIS JOURNAL, **5**, 1639–46 (Dec., 1928).

[2] It is understood that in the present article we shall confine our attention to metals which do not decompose water to any appreciable degree.

positive ions electrostatically. Likewise, the dissolved ions confer a positive charge on the solution, which consequently opposes the entrance of further positive ions. A new balance (but not a true solution equilibrium) is set up. Now only a comparatively small difference in charge between plate and solution is necessary to establish the new equilibrium. Consequently, a balance is reached when so few metal ions have gone into solution that no change in concentration is measurable at all. We see therefore that while a salt will continue to go into solution until a state of saturation is reached, practically no metal at all dissolves in water or in a solution of the metal salt.

The equilibrium which now exists is not a true solution equilibrium. In solution equilibrium:

osmotic pressure $\rightleftharpoons$ *solution pressure*

In the state of affairs which we have described:

osmotic pressure + *electrostatic forces* $\rightleftharpoons$ *solution pressure*

It is as though a grocer were to cause a half-pound of sugar to balance a two-pound weight by affixing a magnet under one pan of his balance. The sugar and the weight would be balanced but they would not be in gravitational equilibrium.

Let us scrutinize in a little more detail the equilibrium between a metal strip and a solution of its salt. We spoke at the outset of the mutually opposing solution pressure and osmotic pressure of a salt. It is evident that at any concentration between infinite dilution and saturation, the solution pressure is the greater of the two. We can therefore imagine an algebraic sum of the two opposing pressures which might be called the *net* solution pressure or tendency of the salt. Similarly, we might imagine a *net* solution tendency for a metal strip immersed in water or in a solution of one of its own salts—provided the salt solution is unsaturated with respect to the true solution equilibrium between the metal and its ions.

At the risk of being tedious, it is necessary to emphasize the point that equilibrium is the true criterion of the saturation phenomenon. The impression that a solution is saturated with a substance when it contains "all of the substance that it can hold" is utterly misleading, and any idea of saturation based upon such an impression will be found hopelessly confusing in the explanation which is to follow. We must distinguish sharply between a salt solution which is saturated with respect to the solid salt and one in which there is saturation equilibrium between metal ions and the solid metal. A solution saturated with zinc sulfate (or any other zinc salt for that matter) is very far indeed from containing enough zinc ions to be in saturation equilibrium with metallic zinc. A saturated solution of silver nitrate, on the other hand, is highly supersaturated from the standpoint of the *metallic silver—silver ion* equilibrium.

In the light of what we have said, it is evident that one of three condi-

tions may prevail when a strip of metal is immersed in a solution of one of its own salts.

(1) If the solution is unsaturated with respect to the true *metal-metal ion* solution equilibrium, the algebraic sum of the solution pressure and the osmotic pressure will be a *net* solution pressure. Metal ions will tend to pass into the solution from the metal strip. That tendency will quickly be counterbalanced by the *negative* charge built up on the zinc plate and the equivalent *positive* charge built up in the solution. It is apparent that the magnitudes of these charges are determined by the magnitude of the *net* solution pressure. A highly unsaturated solution gives rise to a large *net* solution pressure with a consequently large negative charge on the metal plate.

(2) If the number of metal ions present in the salt solution is precisely that necessary for true solution equilibrium with the metal, the algebraic sum of the solution and osmotic pressures will be zero. There will be no net tendency for metal ions either to dissolve or to leave the solution. In such a case no charge at all is built up.

(3) If the solution is supersaturated with metal ions, with respect to the true *metal-metal ion* equilibrium, there will be a net osmotic pressure and a tendency for metal ions to deposit on the metal plate. Since the metal ions are positively charged, their deposition results in the building up of a positive charge on the plate. At the same time, the solution itself becomes negatively charged because of the excess negative ions left behind. The *osmotic* pressure is therefore opposed and counterbalanced by the electrostatic attraction of the negatively charged solution for positive ions and the repulsion of the positively charged plate for additional positive charges, just as we previously saw that *solution* pressure was opposed and counterbalanced by the reverse electrostatic forces. In neither case are sufficient metal ions transferred to make a measurable difference in the concentration of the solution, and in neither case is a true solution equilibrium attained. The magnitude of the positive charge on the plate is obviously determined by the magnitude of the net osmotic pressure which it offsets and which is in turn dependent upon the concentration of the solution.

The Concentration Cell

We see, therefore, that we can vary the potential difference between a metal and a solution of one of its salts by varying the concentration of the salt solution. This fact gives us exactly the opportunity we need in order to be able to produce an electric current. Electrical energy, like heat energy, "runs down-hill" only.[3] In order to accomplish a transfer of

[3] This generalization applies, of course, to all forms of energy. More elegantly expressed, it constitutes the First Law of Thermodynamics.

energy, we must first establish a difference in energy levels. This we can now do.

In order to deal with a concrete example, let us suppose that Figure 1A represents a zinc plate immersed in a very dilute solution of zinc sulfate. Figure 1B represents a zinc plate immersed in a concentrated solution of zinc sulfate. Since both solutions are highly unsaturated with respect to the true $Zn \rightleftharpoons Zn^{++}+2\epsilon$ solution equilibrium, it follows that in each system, the zinc plate is negatively charged and the solution is positively charged. But, since the solutions are of different concentrations, it follows that the charges in A and B will be of different magnitudes. If the previous discussion has not made this consequence obvious, a glance at the following equations will do so. For the system A we may write:

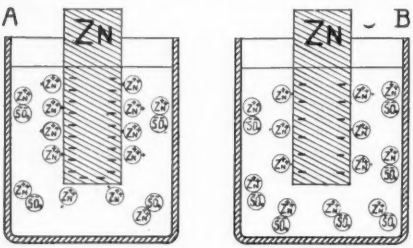


FIGURE 1

$$(\text{solution pressure})_A \rightleftharpoons (\text{osmotic pressure})_A + (\text{electrical charges})_A$$

For B we may write:

$$(\text{solution pressure})_B \rightleftharpoons (\text{osmotic pressure})_B + (\text{electrical charges})_B$$

Now since we are dealing with the same metal in both cases,

$$(\text{solution pressure})_A = (\text{solution pressure})_B$$

Hence:

$$(\text{osmotic pressure})_A + (\text{electrical charges})_A \rightleftharpoons (\text{osmotic pressure})_B + (\text{electrical charges})_B$$

Since the osmotic pressure is directly proportional to the concentration of Zn^{++},

$$(\text{osmotic pressure})_B > (\text{osmotic pressure})_A$$

which necessitates that:

$$(\text{electrical charges})_A > (\text{electrical charges})_B.$$

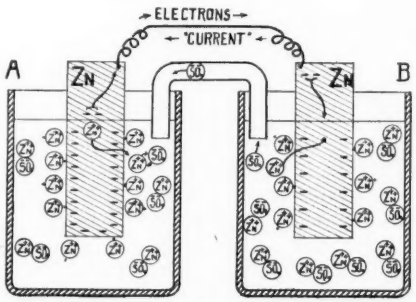


FIGURE 2.—A CONCENTRATION CELL

If, now, we connect the two plates by means of a wire which will permit the transfer of electrons and the two solutions by means of a siphon or "salt-bridge" which will permit the transfer of sulfate ions, a current will flow. In Figure 2 the movements of electrons and negative ions are indicated. The direction conventionally assigned to the current is opposite to the direction of electron transfer. (What would happen if the

metal plates, only, were connected, the salt-bridge being omitted?)

A cell of this type is known as a *concentration cell.* Obviously it develops its greatest E.M.F. when the difference in concentration between the two solutions is greatest, and it "runs down" rapidly as it operates. When the two solutions have arrived at the same concentration, no difference in charge exists between one side of the cell and the other and no further current flows.

An interesting experiment illustrating the action of the concentration cell is described by Professor Mellor.[4] (See Figure 3.)

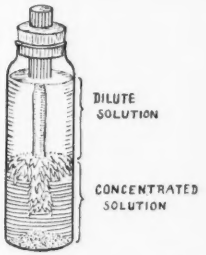


FIGURE 3.—A CONCENTRATION CELL EXPERIMENT

A layer of a concentrated solution of stannous chloride in hydrochloric acid, about 10 cm. deep, is placed at the bottom of a cylinder, and above this a layer of a dilute solution. A rod of metallic tin is fixed through a hole in the cork so that it is suspended axially in the liquid in the cylinder. The rod of tin thus represents both electrodes and connecting wire of a concentration cell. Tin is dissolved by the more dilute solution, and precipitated from the more concentrated solution. The diagram illustrates the appearance of the rod of tin after the vessel has stood a couple of days.

Zinc and zinc chloride do not work so well.

Two-Metal Cells

Since the concentration cell is incapable of delivering a uniform current and since it runs down so quickly, it is of no practical value. A re-examination of the equations (or rather, the equivalencies) on page 120 reveals the fact that in constructing our concentration cell we accomplished the necessary difference in charge between the two half-cells by varying the *osmotic pressures.* The idea of accomplishing a like result by varying the *solution pressures* immediately suggests itself. How can this be accomplished?

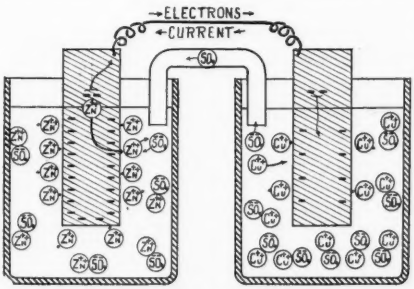


FIGURE 4.—THE ZINC-COPPER CELL

So far we have said little about the fundamental nature of solution pressure—and for the very good reason that little is known on that subject. However, we do know that each metal has its own characteristic solution

[4] "Modern Inorganic Chemistry," J. W. Mellor, Longmans, Green and Co., New York City, 1925, p. 438.

pressure and that these pressures vary greatly in magnitude from one metal to another. Incidentally, the solution pressures vary in the order of arrangement of the "electromotive series."[5] As one proceeds down the table, the solution pressures become smaller. Hence, to vary the solution pressures in our half-cells, it is necessary only to choose different metals for our poles.

Zinc and copper furnish good working examples. Now it is *not* true (as some textbooks state) that a strip of copper immersed in a solution of copper sulfate has a positive charge.[6] Nevertheless, the solution pressure of copper is *very much smaller* than that of zinc. Consequently, the negative charge on an immersed copper plate is much smaller than that on a zinc plate.[7] Hence, if we arrange a cell like that illustrated in Figure 4, current will flow as indicated. (It is not deemed necessary to discuss the operation of this cell in so much detail as was devoted to the concentration cell, since with the exception of the means of producing the difference in charge, the principle of operation is identical.)

The Daniell cell is one form of the copper-zinc cell. Here the necessity for an extra vessel and a salt-bridge is eliminated by placing the denser solution of concentrated copper sulfate in the bottom of a battery-jar and floating the less dense solution of dilute zinc sulfate on top of it. Since the operation of the cell involves the dissolving of metallic zinc and the deposition from solution of copper ions, the concentrations of the respective solutions are so chosen as to favor these processes. The zinc sulfate solution is either very dilute or is replaced by dilute sulfuric acid. The copper sulfate solution is saturated and is kept so by an excess of solid copper sulfate at the bottom of the jar.

The oxidation-reduction cell also falls in the class of primary cells, but we shall not discuss it at this time.

[5] See the fourth article of this series, THIS JOURNAL, **5,** 1645 (Dec., 1928).

[6] For a more detailed treatment of this point, see "Inorganic Physical Chemistry," G. H. Cartledge, Ginn and Company, New York City, **1925,** pp. 311–6, but especially p. 314.

[7] According to the conventional system of nomenclature the B plates in the cells illustrated in Figures 2 and 4 are positive and "current" flows from the B plates to the A plates. Actually, all the plates are negatively charged but the A plates have greater negative charges than the B plates. Electrons flow from the A plates to the B plates.

Lime in Salty Water Saves Iron and Steel. Lime in salty water will prevent the corrosion of iron or steel structures that may be exposed to it, H. O. Forrest, J. K. Roberts, and B. E. Roetheli, of the Massachussetts Institute of Technology, have found. Where there are bicarbonates, or salts containing the metal calcium, in the water, the lime causes a layer of protective scales of calcium carbonate on the iron. Where there is magnesium in the water, soda ash must also be added. The formation of the protective scale is hastened if the water is made somewhat acid.—*Science Service*

WHAT THE CHEMISTRY STUDENT SHOULD KNOW ABOUT PATENT PROCEDURE I. DEVELOPMENT OF OUR PATENT SYSTEM

LLOYD VAN DOREN, WARFIELD & WATSON, 247 PARK AVE., NEW YORK CITY

The outstanding position occupied today by the science of chemistry and the chemical industry in the business of our country and of the world makes it highly desirable—it may be said perhaps even necessary—that our chemical industry be placed on as firm a foundation as possible. There are various ways and there are various factors which will contribute in order to accomplish this result. One of the contributing factors, and perhaps as important if not more important than any other, is the strength of the chemical patents which are granted by our Patent Office on chemical inventions—be they process or product.

This article is the first of a series which will be presented with the object and the hope that therefrom the student of chemistry will acquire at least a somewhat fuller knowledge of chemical patents and the procedure in accordance with which they are granted. The end sought is that when he passes into the industry and, in the course of his duties makes an invention or is placed in charge of others who make inventions, he will be the better able to assist the attorney in whose charge the preparation of the application for Letters Patent is placed. Also he will be the better qualified to evaluate and properly limit the scope of his own inventions and the inventions of others and will be the more competent to perform his own duties and direct the investigative activities of others.

Accordingly, it seems proper to take up the discussion of patent procedure, more particularly as it relates to chemical patents at the point of inception of our present patent system, and it might also be said at the logical starting point, *i. e.*, the Constitution of the United States. It was with remarkable vision and understanding that those charged with the drafting of the Constitution foresaw the requirements which a system should possess in order to insure that the general public and those making inventions would be mutually benefited. Of equal importance was their foresight in providing a system which would be and has been the very foundation of our industrial development and a great incentive to such development. To provide for such a system our Constitution declares that, "The Congress shall have power. . .to promote the progress of science and useful arts by securing for limited times to authors and inventors, the exclusive right to their respective writings and discoveries." This is section VIII of Article I. It was reputed that James Madison was largely instrumental in introducing this provision into the constitution.[1]

[1] Wyman, *J. Patent Office Society*, **IX**, p. 71 (1926–1927).

Most of the present-day patent systems go back historically to the old English system. This, however, does not detract from the foresight and vision of him who wrote the above provision into our Constitution. The English system has developed rather through a process of evolution than logically—it might be said also somewhat irregularly. The aim, however, has always been to foster new industries rather than to directly stimulate inventive genius.

In the sixteenth century the royal purse was frequently in need of replenishment, and a favorite means was by the granting of monopolies in exchange for cash. The abuse of this procedure gave individuals the sole rights to sell the ordinary commodities of life, such as salt, sugar, and tobacco and the royal power was limited quite early through legislation. It is well recognized today that a government monopoly for the sale, for example, of tobacco or matches, or sugar would be highly undesirable, and so it will be realized that the conditions must have been intolerable when all kinds of the usual commodities of life were controlled by individuals through monopoly grants from the crown. The statute abolishing such abuses has now become famous as the "Statute of Monopolies." It, however, made an exception in the recognition that the crown had the power or should retain the power to grant a monopoly to "the true and the first inventor" of "any manner of new manufactures within this realm." The Statute of Monopolies was enacted in the year 1623 and the exception has proved to be of the greatest importance as the foundation upon which the English patent system has been built. It perhaps may properly be said that the whole complex structure of patent law throughout the world is based on this rather slender foundation.

In exercise of the power given to Congress under the Constitution, the first patent law was enacted in 1790. Since then several patent statutes have been enacted from time to time, up to that which we have at present. The early statute provided for no examination as to operability and novelty and it was not required that the individual making the application should himself be the inventor. It is rather difficult to assign a definite time at which the present statute was passed, in as much as there have been changes and modifications at intervals so that in its present form it may be looked upon as the result of a certain process of evolution. However, the main provisions of our present statute were established in 1836, and although changes have been made at various times, the underlying principles have undergone little modification since their enactment. It was in accordance with this Act that our present system of examination as to operability and novelty came into being. The credit for this system, which has been the pattern for many of the patent systems in the world, should be given to Senator Ruggles of Maine.

Sir Robert A. Hadfield of Sheffield, England, one of the world's greatest

inventors, a leading authority on metallurgy, and a steel manufacturer of world-wide reputation, said:

> As showing how Patents for Inventions strike a "new" nation, it may be mentioned that the Japanese Government, when considering the establishment of a patent system on the lines of that created by the American Patent Act of March 1, 1899, appointed Mr. Takanashi their special commissioner to Washington, D. C. On being asked why the people of Japan desired to have a patent system, he replied: "It is only since Commodore Perry in 1854 opened the ports of Japan to foreign commerce that the Japanese have been trying to become a great nation, and we have looked about us to see what nations are the greatest, so that we can be like them, and we said: 'There is the United States not much more than 100 years old, and America not discovered by Columbus until 400 years ago.' We said, 'What is it that makes the United States such a great nation?' and we investigated and found that it was patents, and we will have patents.' " The writer in every way agrees with this wise statement by the Japanese representative and wishes his countrymen would insist upon a British Parliament giving to the British empire a patent law as liberal and as equitable as that of the United States of America.[1]

The early practice, *i. e.*, under the Act of 1790 in connection with the granting of patents, required that each patent be signed by the President, the Secretary of State, and the Attorney General. Thomas Jefferson was Secretary of State, and the duty of examining applications and granting patents resided in his office. Jefferson was much interested in the system, and the early patent applications were all examined by him personally.

As illustrative of the patents granted under the early system, reference may be made to the fourth U. S. patent which was issued to Francis Bailey of Philadelphia on January 31, 1791. The invention pertained to methods for forming punches. It was signed by George Washington as President, Thomas Jefferson as Secretary of State, and Edward Randolph as Attorney General. Each of these early patents also carried a notation that it was delivered to the inventor as of a certain day and the notation in this case is signed by Thomas Jefferson.

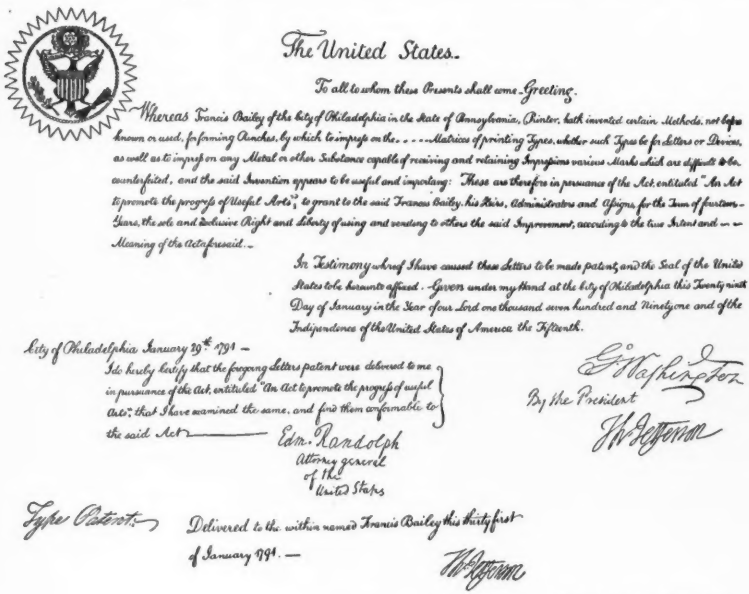
At that time the patents did not go into any very great detail, nor did they contain any claims. The entire description of the patent granted to Francis Bailey is as follows:

> Methods not before known or used for forming punches by which to impress on the matrices of printing types, whether such types be for letters or devices, as well as to impress on any metal or other substance capable of receiving and retaining impressions of all marks which are difficult to be counterfeited, and the said invention appears to be useful and important.

The early granting of patents, up to 1802, was a part of the general clerical business of the Department of State. The Patent Office, as a distinct unit, was created during that year, and Dr. William Thornton became its first superintendent at a salary of $1400 a year by appointment by the Secretary of State, Madison. The Patent Office as a separate bureau

was instituted through the action of James Madison rather than established by law.

About 1810 the Patent Office received a particular allocation as to space when Congress provided for the purchase of accommodations for the General Post Office and for the Patent Office. The space thus provided was occupied by the Patent Office until 1836, when the building was destroyed by fire. Following the destruction of this building, Congress authorized the erection of the present Patent Office building, which consists of four wings enclosing a court approximately 264 by 106 feet in area. This building is at Ninth and F Sts., N. W., Washington, D. C. The



The United States.

To all to whom these Presents shall come Greeting.

Whereas Francis Bailey of the City of Philadelphia in the State of Pennsylvania, Printer, hath invented certain Methods, not before known or used, for forming Punches, by which to impress on the . . . . Matrices of printing Types, whether such Types be for Letters or Devices, as well as to improve on any Metal or other Substance capable of receiving and retaining Impressions various Marks which are difficult to be counterfeited, and the said Invention appears to be useful and important: These are therefore in pursuance of the Act, entitled "An Act to promote the progress of Useful Arts," to grant to the said Francis Bailey, his Heirs, Administrators and Assigns, for the Term of fourteen Years, the sole and exclusive Right and Liberty of using and vending to others the said Improvement, according to the true Intent and — — Meaning of the Act aforesaid. —

In Testimony whereof I have caused these Letters to be made patent, and the Seal of the United States to be hereunto affixed. — Given under my Hand at the City of Philadelphia this Twenty ninth Day of January in the Year of our Lord one thousand seven hundred and Ninety one and of the Independence of the United States of America the Fifteenth.

G° Washington

By the President

Th: Jefferson

City of Philadelphia January 29th 1791 —

I do hereby Certify that the foregoing Letters patent were delivered to me in pursuance of the Act, entitled "An Act to promote the progress of useful Arts," that I have examined the same, and find them conformable to the said Act ——— Edm: Randolph Attorney General of the United States

Types Patented

Delivered to the within named Francis Bailey this thirty first of January 1791. —

Th: Jefferson

Robb's Patent Essentials

FOURTH UNITED STATES PATENT ISSUED 1791

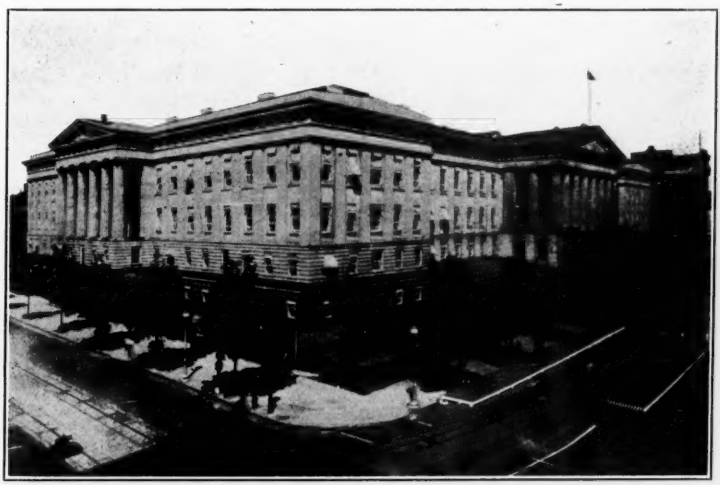
first wing was completed in 1840; a second wing in 1852; a third in 1856; and the fourth wing in 1867.

The present series, in accordance with which our patents are numbered, began subsequent to the passage of the Act of 1836. The term of the patents was for a period of fourteen years, with the privilege of extending this period for a further period of seven years upon request. Should the inventor so desire, he might obtain, under the early patent laws, a grant for a period of twenty-one years. In 1870 the patent statutes were modified. The privilege of renewing a patent was withdrawn and the term

definitely set for seventeen years. Our patents since then have been granted for this term.

The first patent, under what may be termed the present statute, was granted on July 13, 1836, to John Ruggles of Thomaston, Maine, "For Traction Wheels," specifically "Locomotive Steam Engine for Rail and Other Roads." It is patent No. 1.

At the beginning of the present century, 640,166 patents had been granted. Patent No. 1,000,000 was granted on August 8, 1911, to Francis H. Holton of Akron, Ohio, for a "Vehicle Tire." The last patent granted in the issue of December 4, 1928, bears the number, 1,694,363. This illustrates the growth in patent practice, in as much as it will be noted



Harris & Ewing, Washington, D. C. *Courtesy of the Journal of the Patent Office Society*

U. S. PATENT OFFICE BUILDING

that seventy-five years were required to issue the first million patents, whereas it has required only a little more than seventeen years, or since August 8, 1911, to grant 694,363 patents. Patents at the present time are being granted at the rate of from 750 to 950 a week. This shows the vast amount of work which is required of the examining corps in the Patent Office, but it does not evidence by any means the entire amount of such work, because there are many applications filed which do not mature into patents. This is for various reasons, and perhaps largely because the examiners in the Patent Office find that the subject matter is unpatentable, but it is frequently for the reason that the inventor or his as-

signee prefers to abandon the application rather than have it appear as a patent.

The story is told of an examiner in the Patent Office, who, about the year 1845, decided to resign from his position and did so. Shortly thereafter, upon meeting an intimate friend, he was asked by this friend as to his reason for resigning. The friend stated that he appeared to have a very good position and one in which he had pleasant associations and enjoyed his work. To this the examiner replied that he had reached the decision to resign because apparently everything possible to be invented had been invented and there would soon be no work for the examiners in the Patent Office. At the end of that year patent No. 4347 was granted, and in as much as Patent No. 1,694,363 has now been granted, one may form his own conclusion as to the wisdom and foresight of this examiner.

It may seem a bit inconsistent and paradoxical to state that the field of invention becomes wider as the number of inventions in that field increases. At first thought it would seem as though the situation really should be that the more inventions there are in a given field, the narrower that field becomes. However, each invention disclosed, in the same way as each piece of research undertaken and disclosed to the world, makes possible the disclosure of several additional inventions, so that that which is apparently a paradox is rather a reality.

According to the patent statutes, an individual, if the Patent Office considers him to be the first inventor of an alleged invention, is granted a patent whereby there is bestowed upon him the *prima facie* right to a monopoly of the fruit of his labors for seventeen years. It is frequently thought and expressed, erroneously however, that a patent grants to the individual the right to make, use, and vend that which constitutes his invention. This right was already his because it was the fruit of his own labor and came to him under the common law. What the patent does grant to an individual is the right to exclude all others from making, using, and vending that which constitutes his invention for a period of seventeen years. Stated somewhat differently, a patent grant is a contract which is entered into between the government on the one hand, representing the people of the United States, and the inventor on the other hand. The inventor is permitted to exclude all others from practising that which he has invented, for the consideration that he disclose that which he has invented in sufficient detail that at the expiration of the patent the public may be able to avail itself of the benefits of the invention.

Manhood, not scholarship, is the first aim of education.—*Ernest Thompson Seton*

SULFUR MINING

The ingenious process employed in the mining of American sulfur is the invention of Dr. Herman Frasch. Sulfur had first been discovered in Louisiana and Texas in the course of unsuccessful drillings for oil. Numerous companies had been formed to exploit these sulfur deposits and had tried without success to pattern their operations after those of the Sicilian sulfur mines, where the digging of sulfur is quite as simple as the digging of coal. Unfortunately for these earlier efforts, the major portion of the sulfur area is overlaid with large deposits of quicksand, which makes the sinking of shafts almost impossible.

Dr. Frasch was no novice in the field of chemical industry. He already had an impressive list of patents to his credit, when he resolved to initiate some experiments looking toward the production of sulfur from these hitherto disappointing deposits. This work was undertaken as a side-line to his regular duties as chemist for the Standard Oil Company.

The final success of the venture, together with his numerous other contributions to industrial chemical processes, led to his receipt of the Perkin medal in 1911. In his address of acceptance at that time he recounted his experiences in rendering available one of America's important natural resources. The account which follows is extracted from that address.[1]

"I realized at the outset that a method entirely different from that employed in the mines of Sicily was necessary for success here, as the class of labor required to operate this mine would demand at least $5.00 per day, while the Silician miners were being paid 60 cents.

. . . . . .

"At that time the drilling of a well in an alluvial deposit containing quicksand, etc., was a very tedious task, and it took from six to nine months to get through the alluvial material to the rock—work which we do now in three days.

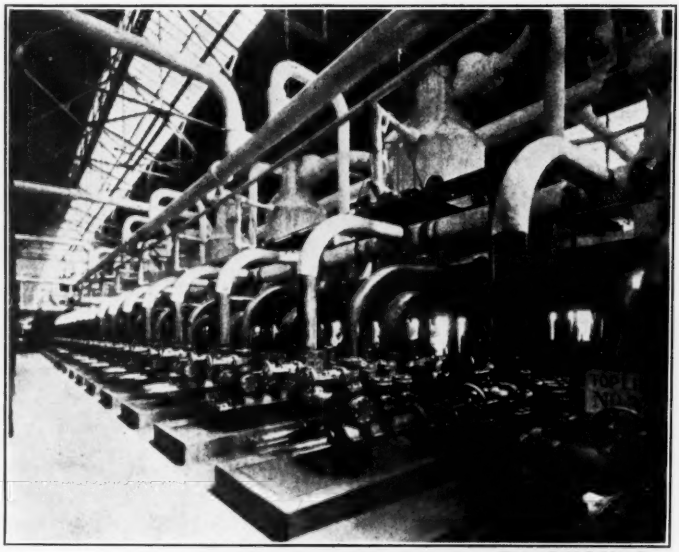
"I drilled a well through the alluvial deposit to the rock with a 10″ pipe, then continued through the sulfur deposit, which was about 200 feet thick, with a 9″ drill, and immersed a 6″ pipe from the surface to the bottom in this well. The 6″ pipe had a strainer only 6″ long, at the very bottom, and a seat to receive the 3″ pipe through which we expected to lift the sulfur to the surface. The 6″ pipe, directly above the seat for the 3″ pipe, was also perforated for a distance of three feet.

"After the well had been drilled and before the pipes were inserted, it was filled up with sand in order to insure a tight receptacle at the bottom for the liquid sulfur. After the sand had been washed out, the pipes were inserted and equipped, and the well was ready for the melting fluid.

[1] *Ind. Eng. Chem.*, **4**, 134–40 (1912).

"This melting fluid consisted of water superheated to 335° Fahrenheit. The porosity of the rock in which the melting had to be done seemed to furnish an almost insurmountable obstacle to success, as I feared that the wild waters in the rock would break into the melting zone I expected to create and reduce the temperature of the fluid with which I expected to melt below the temperature necessary to fuse the sulfur. I had supplied a large number of boilers to furnish the heat necessary to maintain in the well a temperature higher than that required for the fusion of the sulfur.

"The water was superheated in columns in which 100 pounds per square inch pressure was maintained, and the apparatus which I had constructed



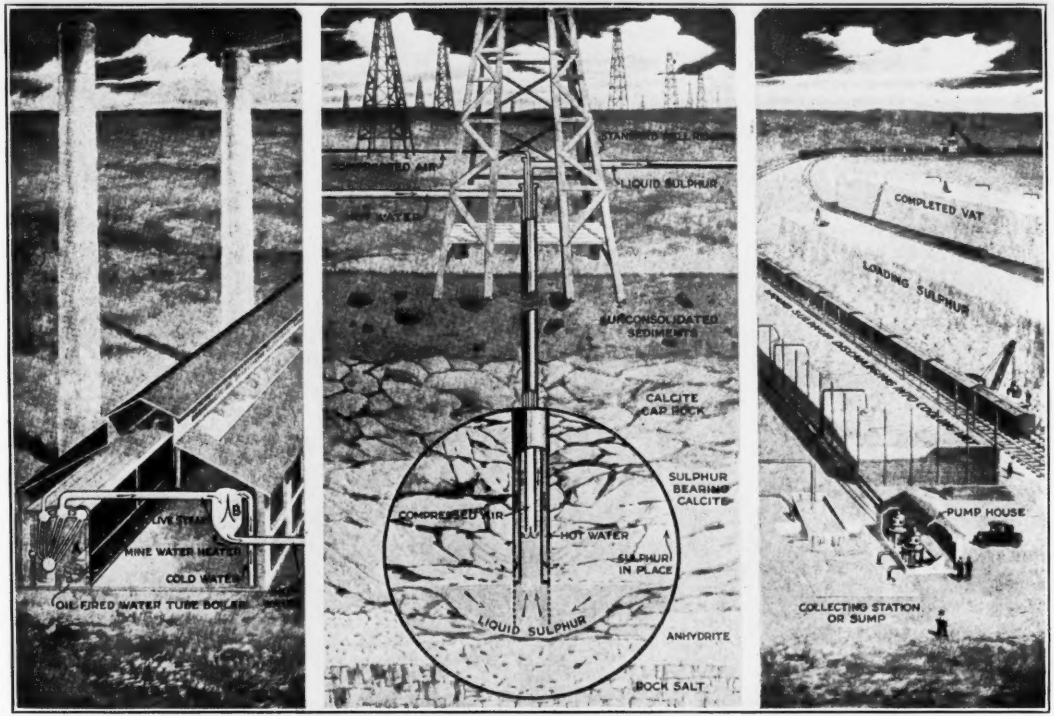
Texas Gulf Sulfur Co.

MINE-WATER HEATERS

to accomplish this proved very efficient. We used twenty 150 h.p. boilers for a well, which represents experimentation on a ponderous scale.

"When everything was ready to make the first trial, which would demonstrate either success or failure, we raised steam in the boilers, and sent the superheated water into the ground without a hitch. If for one instant the high temperature required should drop below the melting point of sulfur, it would mean failure, consequently intense interest centered in this first attempt.

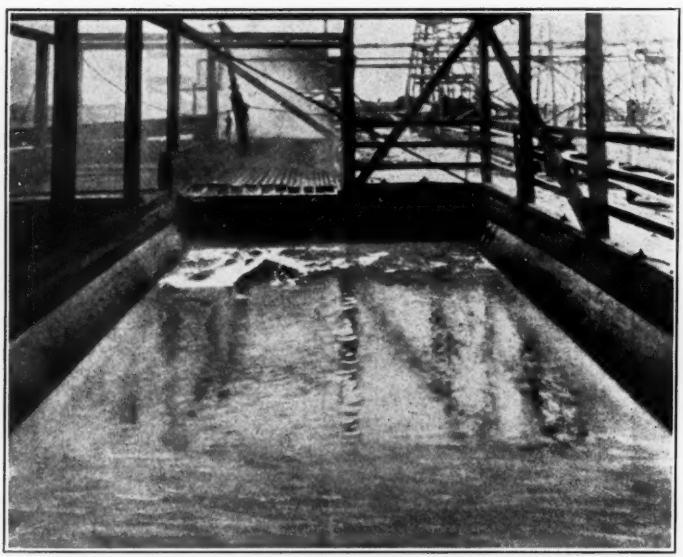
"After permitting the melting fluid to go into the ground for twenty-four hours, I decided that sufficient material must have been melted to produce



Copyright, 1925, by Texas Gulf Sulfur Co., Inc.

Steam generated in "A" is passed into "B" where it heats cold water to a temperature of about 325°F. The hot water from "B" is pumped down the outer of three concentric pipes, to the sulfur formation which it enters through openings in the pipe. The sulfur thus melted, being heavier than water, collects at the bottom of the well. Compressed air introduced through the center pipe forces the liquid sulfur to the surface where it is collected in sumps. Centrifugal pumps lift the sulfur into the vats, where it solidifies and is later broken down for shipping.

some sulfur. The pumping engine was started on the sulfur line, and the increasing strain against the engine showed that work was being done. More and more slowly went the engine, more steam was supplied, until the man at the throttle sang out at the top of his voice, "She's pumping." A liquid appeared on the polished rod, and when I wiped it off I found my finger covered with sulfur. Within five minutes the receptacles under pressure were opened, and a beautiful stream of the golden fluid shot into the barrels we had ready to receive the product. After pumping for about fifteen minutes, the forty barrels we had supplied were seen to be inadequate. Quickly we threw up embankments and lined them with



Texas Gulf Sulfur Co.

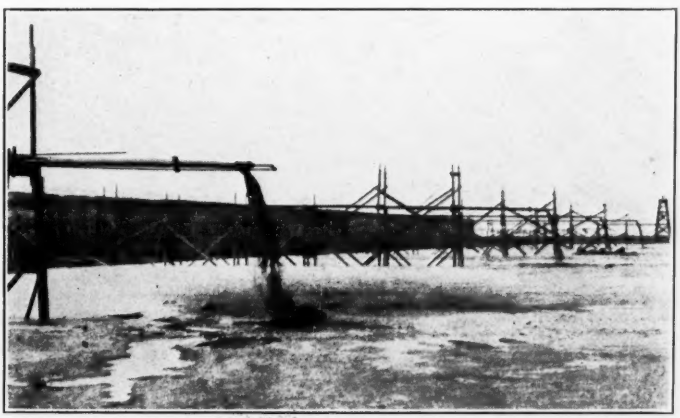
PUMPING STATION SUMP

boards to receive the sulfur that was gushing forth; and since that day no further attempt has been made to provide a vessel or a mold into which to put the sulfur.

"When the sun went down we stopped the pump to hold the liquid sulfur below until we could prepare to receive more in the morning. The material on the ground had to be removed, and willing hands helped to make a clean slate for the next day. When everything had been finished, the sulfur all piled up in one heap, and the men had departed, I enjoyed all by myself this demonstration of success. I mounted the sulfur pile and seated myself on the very top. It pleased me to hear the slight noise

caused by the contraction of the warm sulfur, which was like a greeting from below—proof that my object had been accomplished. Many days and many years intervened before financial success was assured, but the first step towards the ultimate goal had been achieved. We had melted the mineral in the ground and brought it to the surface as a liquid. We had demonstrated that it could be done.

"This was especially gratifying as the criticisms I had received from technical papers and people who had heard of what I was attempting to do had been very adverse. Every one who expressed an opinion seemed to



Texas Gulf Sulfur Co.

SULFUR DISCHARGING INTO A VAT

be convinced that this thing could not be done, one prominent man offering to eat every ounce of sulfur I ever pumped.

. . . . .

"At first we pumped with an ordinary deep-well oil pump, changed to meet the corrosive action of the sulfur. We experienced great difficulty with the valves in the pump, the high specific gravity of the sulfur, the great depth from which it had to be raised, and the corrosive action of the mineral itself making the maintenance of valves very difficult. Zinc and aluminum are practically the only two metals unaffected by liquid sulfur, but both these, being soft and easily disintegrated, would not withstand the shock at the change of stroke of the pump. I decided that if the specific gravity of the sulfur could be lowered by the admixture of some other body much lighter, a point might be reached where the hydrostatic pressure of the water in the ground would raise the sulfur. Air seemed the most suitable, and we introduced compressed air into the

column of liquid sulfur standing in the well, using a volume of two parts of air and one of sulfur. We have raised our sulfur discharge lines 70 feet above the ground, so that we can fill bins to a height of 65 feet without machinery or pump of any kind in the sulfur proper.

"The first well lasted long enough to demonstrate the possibility of success, and to indicate in what direction improvements must be made. At that time, my sulfur enterprise was merely a hobby, the bulk of my time being devoted to my Standard Oil work.

"Many difficulties arose which we had not foreseen. We lost some wells because of the parting of the pipes. As the mineral was melted from the bottom, the earth above would follow as the sulfur rock settled. The grip of the sand and earth against the pipe was so great that instead of

Texas Gulf Sulfur Co.

SULFUR READY FOR LOADING

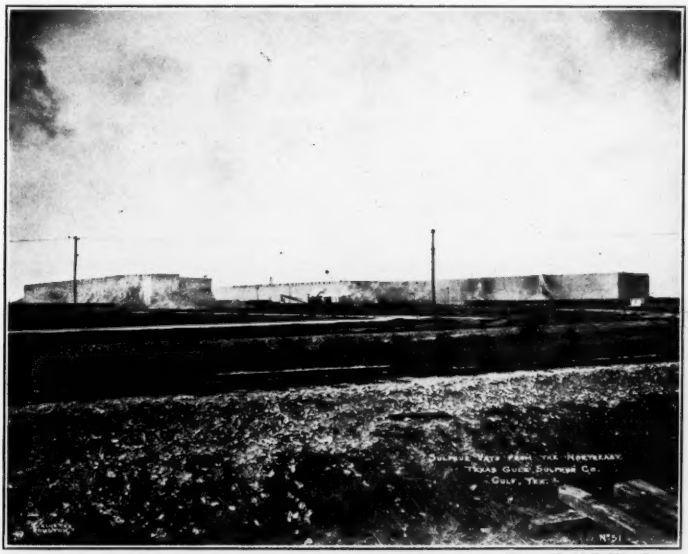
sliding, it would pull the pipe in two and the well would be lost. A 12" pipe outside of the 10", with stuffing box and telescope joints, obviated this difficulty. All wells, however, are eventually broken and crushed, when the abstraction of sulfur becomes so great that the cavity made cannot withstand the weight of the ground above it.

"We succeeded in increasing the life of a well greatly by lining the hole drilled through the rock with a 9" perforated pipe.

"About that time we found that some wells gave out and ceased to pump when there had been no breaking of the pipes. I reached the conclusion that the cold sulfur water permeating the rock had broken into the melting zone, and brought the temperature of the melting water below the melting point of sulfur. I thought this might be remedied by pumping large amounts of a material like sawdust into the mine with the melting

fluid, and that if the quantities of sawdust were large enough, the channels through which the wild waters in the rock entered the melting zone could be sealed.

"One well, after pumping about 7000 tons, at the rate of approximately 350 tons per day, ceased to produce. The pipes were all in good order, and we started to pump sawdust into the ground with the melting water. After pumping in about six carloads per day for five days, the well "sealed"



Texas Gulf Sulfur Co.

SULFUR VATS

with sawdust and promptly produced 39,000 tons more before the caving of the rock broke the pipes.

. . . . .

"During the long intervals which necessarily elapsed between my visits to the mine, I could give this new enterprise no attention. It took months to drill a new well when an old one was lost. At one time the work lay idle for a whole year before I could take it up again, and it was not until 1903 that we could see financial success ahead. In that year we produced 35,000 tons, and in 1904, enough to supply the entire consumption of the United States. It was in that year that we sent the first cargo of American sulfur to France."

Present practices in sulfur mining differ but little from the process

developed by Dr. Frasch. The following description is quoted from "Mining of Sulfur," a pamphlet issued by the Texas Gulf Sulfur Company.

"The feed water delivered by the pumps to the mine-heaters is preheated above river temperature by exhaust steam. In the heater, steam is introduced at boiler pressure. Water and steam enter separately and mix in the dome of the heater. The high-temperature water is discharged from the heater through a series of so-called "booster" pumps—set below the heaters and parallel to the row of feed pumps—into six-inch pipe lines leading out to the mining area, down the wells, into the sulfur deposit. The actual volume of water required by any given well is largely governed by the conditions under which the well may be operating, these conditions being affected by local characteristics of the sulfur formation in which the well is situated, and by other variables that introduce themselves from time to time as the well continues pumping.

. . . . .

"The underground well equipment consists of pipes of various sizes, placed concentrically, and extending from the surface of the ground into the sulphur deposit. The system might be described as a nest of pipes. A ten-inch or an eight-inch casing extends to and rests on the top of the caprock. Inside this casing a pipe of smaller diameter passes below the lower end of the casing, through the sulfur-bearing stratum, and rests in the upper portion of the barren anhydrite. A still smaller pipe passes through the second string, there being an annular space between the two, extends nearly to the bottom of the sulfur-bearing rock and rests on a collar which seals the annular space on the outside of this pipe. Finally, a one-inch air pipe, inside all the others, extends to a depth slightly above the collar which forms a seat for the third string last above mentioned. The second string of pipe which passes below the casing and is set in the barren anhydrite, is adequately perforated at two different levels separated by the annular diaphragm, the upper set of holes permitting the escape of the hot water and the lower the entrance of the molten sulfur.

. . . . .

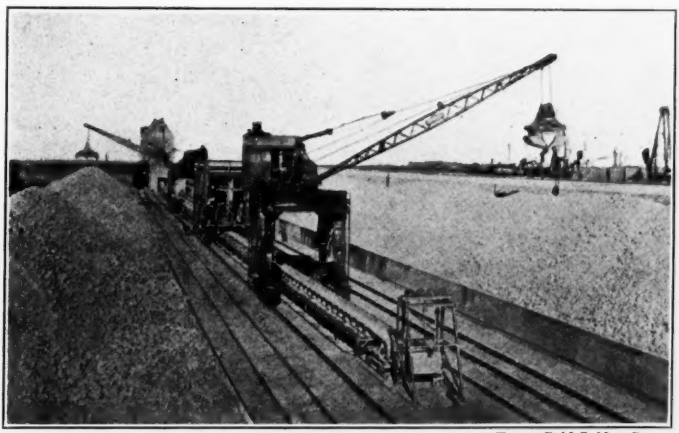
"As extraction of the sulfur proceeds, the integrity of the rock structure is weakened and its subsidence results in a general downward creep of the overlying formations, inequality of movement in which different strata are involved, finally bending or breaking the pipe so as to put the well out of service.

"Subsidence is a disadvantage in mining in so far as it causes the loss of producing wells and the failure of equipment. This disadvantage is offset by the fact that the soft plastic formation immediately above the crumbling caprock, as it yields under pressure due to the overburden occupies the voids left by the extraction of the sulfur, thus reducing the amount of hot water required to fill the porous rock.

"However, this condition of subsidence as a factor in the actual mining operation does not rule at all of the sulfur deposits now being mined. In some cases the barren rock above the sulfur stratum is so thick and of such a character that it is not crushed when the sulfur below is removed. Production costs in mining such deposits are greater than in those where subsidence takes place readily.

. . . . .

"Sulfur from the wells is collected at pumping stations. The discharge lines from the wells deliver the sulfur into sumps at these points. A group of wells may discharge at one pumping station. The stations are located close to the area being steamed, usually within a few hundred yards of the most distant tributary well.



Texas Gulf Sulfur Co.

GALVESTON LOADING PLANT

"The sump is dimensioned to suit the operating conditions, number of wells supplying sulfur, and so forth. The lining may be any suitable material, and concrete has been used successfully. Steam coils on the bottom and at the sides of the sump are required to keep the sulfur in the liquid state.

. . . . .

"Sulfur from the pumping station is delivered to the vats through well insulated pipe lines, each carrying internally a small pipe in which live steam is flowing for the purpose of keeping the sulfur well heated so that it will move freely with minimum friction. These lines discharge directly on the vats. In fact, a vat is formed by the solidification of this liquid sulfur in a wooden bin. The sulfur is pumped into the bin at a rate which

increases the height a few inches per day, the slight vertical increment being a consequence of large horizontal area which provides maximum cooling surface, and involves ample tonnage capacity. As the sulfur solidifies, it gradually builds up into a great block of solid sulfur, bright yellow in color. The wooden vat-walls are built up slowly and are kept but a few inches higher than the sulfur. They are tied into the sulfur by means of short planks. When a vat is complete and ready to be shipped, these wooden walls are removed. In a solid state the sulfur, of course, requires no support and a large block will stand indefinitely with its wooden skin peeled off.

. . . . .

"Vat dimensions vary, and will naturally be governed by the methods followed and the scope of the operation carried on. The vat shown is 800 feet long. Sulfur for shipment is blasted from the face of the vat as required. A block from 12 to 20 feet thick is removed at one time. Holes are drilled back from the face of the vat at suitable intervals apart. Each hole is charged with powder and exploded. Most of the sulfur is thereby broken into pieces of a size suitable for loading. Large pieces are broken with picks to sizes which can be conveniently handled by the clamshell buckets of the cranes. Locomotive cranes load the sulfur into railroad cars."

THE PRODUCTION AND USES OF SULFUR

It may be interesting to the reader to note the extent to which the United States has become an exporting rather than an importing nation so far as sulfur is concerned. The following ten-year record from *Chemical and Metallurgical Engineering*[1] is quoted to furnish raw material for those who enjoy laying things end-to-end.

Year	Production (Tons)	Domestic Consumption (Tons)
1917	1,134,412	968,615
1918	1,353,525	1,135,672
1919	1,190,575	453,622
1920	1,255,249	1,040,219
1921	1,879,150	668,675
1922	1,830,942	865,920
1923	2,036,097	1,146,780
1924	1,220,561	1,051,544
1925	1,409,240	1,228,469
1926	1,890,057	1,495,721
1927	2,000,000	1,350,000

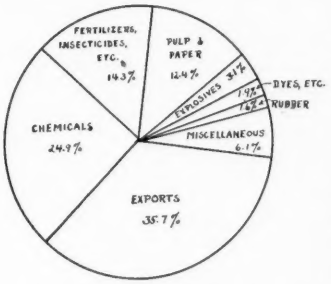
[1] *Chem. & Met. Eng.*, **35**, 62 (Jan., 1928).

The accompanying "pie" (below) is from the same source and designates in more detail the fate of the sulfur which the preceding table disposes of under the non-committal heading, "Domestic Consumption." The figures in the chart are those for the year 1927.

Since much of the sulfur mined finds its way into use in the form of sulfuric acid the following table may also be of interest.[2]

Fertilizers	2,059,000	1,925,000
Petroleum refining	1,325,000	1,350,000
Chemicals	750,000	725,000
Coal products	742,000	732,000
Iron and steel	740,000	685,000
Other metallurgy	725,000	700,000
Paints and pigments	200,000	210,000
Explosives	190,000	183,000
Textiles	120,000	135,000
Miscellaneous	317,000	290,000

Sulfur is not entirely confined to chemical uses. Concealed in the miscellaneous classes are uses which promise to grow as time goes on. The following quotation from the *Industrial Bulletin* of Arthur D. Little, Inc. (March, 1928), enumerates some of them.[3]



USES OF AMERICAN SULFUR—1927

"Although sulfur is one of the cheapest raw materials, its use has, until recently, been almost wholly confined to that of a chemical reagent, as in the manufacture of sulfuric acid, sulfite wood pulp, and vulcanized rubber. It has, however, lately been applied to the impregnation of paper board, upon which it confers great rigidity and strength, while cotton fabrics similarly treated have been successfully tested for the protection of pipe lines from corrosive agencies.

"Sulfur itself in its usual elemental form lacks strength and is easily broken down. When, however, it is properly supported in a porous vehicle, such as paper board or Portland cement, it not only adds greatly to the strength of the carrier, but enables the combined structure to resist the action of many destructive chemicals. Concrete containing 15 per cent of cement has shown, when impregnated with sulfur, ten times the tensile strength of plain specimens.

[2] *Ibid.*, **35,** 59 (Jan., 1928).

[3] See also "Wonders from Molten Sulfur," *Pop. Sci. Mo.*, **113,** 26 (Dec., 1928).

"Wood may be impregnated with sulfur by methods similar to those in use for timber preservation, and as sulfur melts at a temperature a little above the boiling point of water to a mobile liquid, there is little difficulty in securing effective penetration. Wood thus treated should prove useful in the construction of pickling tubs for the metal industries and for tanks in chemical works.

"Large electrolytic cells made of concrete impregnated with molten sulfur have been in successful use for two years."

STUDENT CONTRIBUTIONS

Is your chemistry club carrying on some worthwhile project? Have you, yourself, an interesting chemical hobby? Have you devised an original chemical experiment or piece of apparatus? Have you built a working model of a chemical plant or a piece of chemical machinery? Have you a chemical collection of any kind?

Tell us and other students about it in an article of not more than one thousand words. If possible, illustrate your article with drawings or photographs, or both. In preparing your manuscript, observe the directions to authors set forth on page 2.

Ten dollars will be awarded the high-school or undergraduate college student contributing the best item received on or before February 15, 1929. Five dollars will be paid for any other articles accepted for publication. Address your contribution to the Associate Editor, JOURNAL OF CHEMICAL EDUCATION, the Johns Hopkins University, Baltimore, Md.

Big Tree Bark Resembles Asbestos. The bark of a California Big Tree is, on large specimens, as much as three feet thick and is almost as resistant to fire as asbestos. A sample of the bark, twelve inches square, was placed in a lumber mill furnace, surrounded with dry pine and fir wood and burned for eight hours. When taken from the furnace the Big Tree bark was merely charred on the outside.

This resistance to fire is one reason for the longevity of the California Big Tree, which is known to attain an age of four thousand years and may reach six thousand or more. A mature specimen, twenty feet or more in diameter, sustained scores of forest fires in the days before the national parks and forests were protected.

Other conifers of the western mountains, notably the sugar pine, yellow pine, red and white fir, also possess thick fire-resisting bark. But the *Sequoia gigantea* is the Shadrach, Meshac, and Abednego of the forest world.—*Science Service*

TEXTILES AND TEST TUBES.* PART I

PAULINE BEERY MACK, PENNSYLVANIA STATE COLLEGE, STATE COLLEGE, PENNSYLVANIA

"What stuff wilt have a kirtle of? I shall receive money o' Thursday," said Falstaff to Doll Tearsheet in an expansive moment, in Shakespeare's "Henry the Fourth."

When the events of this play were supposed to have taken place, there were but four textile fibers from which one could fashion a kirtle. These fibers were all found in nature and they were wool, linen, silk, and cotton. At the present time, these natural fibers are used in larger quantities than ever before. In addition to these, a large number of synthetic fibers—the products of the chemical laboratory—has been placed at our disposal.

The synthetic textile fabrics are so attractive that the modern woman would scarcely be disturbed at all, as far as her personal wardrobe is concerned, if the supply of natural fibers were cut off altogether. The man, on the other hand, still depends almost entirely upon wool for making his outer garments, and upon cotton for his underwear; but he draws heavily upon rayon for his ties, socks, and hatbands. Then, too, the recent work which has been done toward the making of synthetic wool substitutes, and the recent interest displayed by at least some men in rayon underwear may indicate that the entire human family might some day be clad entirely with textiles from test tubes.

Whether or not it ever comes to pass that all mankind clothe themselves entirely in synthetic products, the chemist will ever stand ready to make whatever textile fibers are needed to piece out nature's supply. By placing artificial products on the market at very low prices, he has already done more than any other single agency toward making a democracy of all the peoples of the world.

Early Clothing

In reviewing the history of synthetic fibers, it is interesting to go back to the earliest times and consider briefly the history of textile fibers in general.

When members of the human race first began to clothe themselves (we will leave the philosopher to speculate as to whether heat, cold, modesty, rain, or insect pests prompted them to do so) they took from Mother Nature whatever she had to offer for the purpose. The skins of animals, the leaves of trees, tall grasses—were all doubtless used at some time or other by various races in the early stages of their progress.

* This article is an elaborated revision of a paper read before the Institute of Chemistry at State College, Pennsylvania, July 26, 1927. The original paper was published in the *Chemistry Leaflet*, **1**, No. 14 (Jan. 14, 1928).

Skins.—Whatever variations may have occurred among different tribes, however, the skins of animals undoubtedly afforded the first costuming material of widespread use. Because skins used without treatment of some sort soon became stiff and harsh and were also prone to putrefy, the process of tanning was worked out through centuries of tedious rule-of-thumb methods, and was an old industry when histories began to be printed.

Felts.—From the earliest times, leather has held first place for sandals and shoes, but as a general clothing material it early proved itself to be rather inadaptable. Some inquisitive prehistoric member of the human race, however, found out that he could take the woolly fibers from the skins of the ancient forerunners of our modern sheep and beat these together into a matted felt. This felt made a better garment than the hide from which it came. The felting properties of wool are due to the presence on the fiber of a covering of microscopic scales, which hook together and form an entangled mass.

Early Spinning

But even felt is not ideal for making garments for general wear. It must have been the deft fingers of some prehistoric woman who first dis-

ANCIENT WEAVING AND SPINNING, FROM AN EGYPTIAN ENGRAVING IN STONE OF 4000 YEARS AGO

covered that wool fibers could be twisted into a continuous thread. The first threads that investigative fingers spun, however, may have remained curiosities for a long time before it was found that woolen threads could be woven into cloth.

Woolen garments were quite warm and comfortable for cool climates, and they must have given considerable satisfaction to ancient peoples as is the case even today. It was only in comparatively recent times, however, that the chief cause of the warmth of fibers became known. This warmth is also a result of the same microscopic scales which cover the fibers, and which were mentioned above in connection with felting. Underneath each minute scale is a tiny space where air is entrapped. Since air

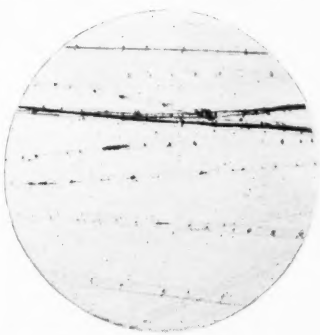
is a poor heat-conductor, this helps wool to serve as an excellent protection against cold.

The ancients, of course, knew nothing of microscopes or of the physical structure of the wool fiber, but they accepted the fact that wool was warm and made the most of it. About the chemical structure of wool, the ancients likewise knew nothing. We cannot boast of knowing very much about this point even today. We are fairly sure that the wool fiber consists of one or a number of protein substances which we group together as one substance which we call *keratin*. To this little-understood substance we assign the empirical formula $C_{42}H_{157}N_5SO_{15}$, because this is in accord with the elementary analysis of the fiber. It remains for some chemist—perhaps to some present-day student of chemistry—to determine just how these atoms are arranged within the molecule.

MICROPHOTOGRAPH OF THE WOOL FIBER

But back to the ancients.

Although wool was used by the Egyptians, it was considered unclean by this race and it was used by them only to make outer cloaks. The Egyptian priests would not permit a fiber of it to be used for any part of their clothing. Even the common people seldom wore it next to their skins, and the outer woolen wraps which they wore had to be left outside the temple when they went in to worship. Woolen garments were further discriminated against by never being buried with their dead.



MICROPHOTOGRAPH OF THE LINEN FIBER

Linen

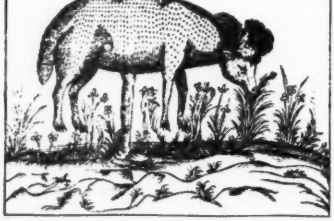
Because of their aversion to wool, the Egyptians were therefore never noted for their woolen fabrics. They were, however, very famous for their linens. When Solomon, at the height of his glory, wished to import the finest textile fabric made anywhere in the world, he sent for Egyptian linen. It has never been rivalled in evenness of threads, for it was without knot or break. Egyptian linen thousands of years old is still in existence, and it is said to excel in

texture even the finest of modern linens, although it is darkened with age.

Linen differs from wool in that it comes from the plant instead of the animal world. Linen fibers are derived from the inner bark of the flax plant, where they occur as bast fibers. Their function is to serve as conveyers of plant foods from one part of the stem to another. They consist chemically of a substance called cellulose, to which the modern chemist has assigned the formula $(C_6H_{10}O_5)_x$. (The x in this equation is another confession of ignorance on the part of the chemist as to how many of the $C_6H_{10}O_5$ units are found in the entire molecule.)

Flax fibers are separated from each other by soaking the flax in water for some time. A process of rotting or, as it is sometimes called, "retting" takes place. This makes it possible to pull the fibers apart and prepare them for weaving.

Unbleached linen is tan in color. It may be bleached by spreading the fabric on the grass in the sunlight for some days. In modern times it has been found to be possible to bleach linen more quickly by a chemical process, but the fabric bleached in this way loses something of its wearing qualities.



DRAWING FROM A FIFTEENTH CENTURY HERBAL, SHOWING ONE OF THE POPULAR CONCEPTIONS OF THE "LAMB TREE" OR COTTON PLANT OF THE TIME

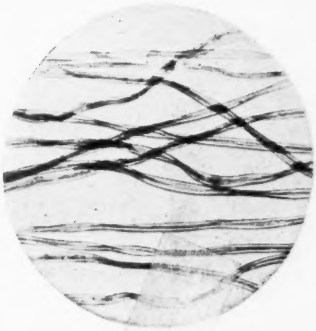
Tree Wool

Cotton is another common textile fiber of plant origin. The wild plant from which it was secured came originally from India. When Herodotus, a Greek historian, visited India about the fifth century, B.C., he described cotton as follows: "And further, there is a tree which grows wild there, the fruit whereof is wool exceeding in beauty and goodness that of sheep. The natives make their clothes of this wool tree."

The description which Herodotus gave to the cotton plant was spread about by word of mouth among the various countries of Europe for many generations. Even after the inhabitants of India had begun the extensive cultivation of the cotton plant, and were exporting cotton to Europe in large quantities, Herodotus' description of the source of this plant was still being repeated. Like many a tale which grows with the telling, this description came to have no resemblance to the original. People began to call the cotton plant the "lamb tree" and to tell fictitious stories about the way in which lambs grew on its branches. Each night, so ran the tale, the branches of this tree would bend down, and the lambs would graze on the grass. The next morning, they would straighten up again. As

late as the fifteenth century, a writer on scientific subjects published a book in which he included a picture of a "lamb tree," drawn to suit the popular notion of what a cotton plant should look like. Later when Europeans began to travel more extensively, visitors to India saw the cotton plant, and the old fable about its nature ceased to be believed.

Although the cotton fiber comes from a different part of the plant than do the linen fibers, its importance to the plant itself is no less great. This fibrous growth which was present on the seeds of the wild plant from which cultivated cotton descended, served as a means of scattering the seed by the agency of the wind. This made it possible for seeds to find lodgment in suitable soil, and thus helped to reproduce the plant. When cotton came to be cultivated, man selected his seeds from plants whose pods were filled with the most plentiful and best fibers. By a careful selection of seeds year after year, growers of the cotton plant succeeded in producing much better fibers than those of the wild cotton plant.



MICROPHOTOGRAPH OF A COTTON FIBER

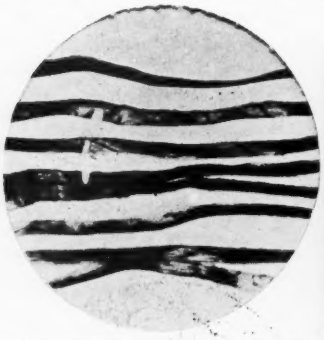
Cotton is almost identical with linen in chemical composition, a fact which makes it practically impossible to distinguish these fibers one from another by chemical means. They can easily be distinguished from each other by means of the microscope, however. Linen is composed of cylindrical cells cemented together end to end, and resembling bamboo when magnified. Through the microscope, cotton appears like a collapsed, spirally twisted rubber tube. This natural twist makes it quite suitable for spinning.

Silk

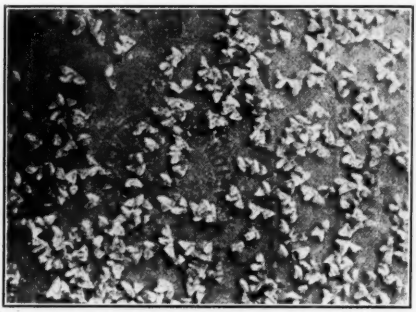
Early History.—Silk is another fiber which has been used for spinning cloth from very ancient times. Silk, like wool, is of animal origin. It is spun *as long continuous fibers* by certain kinds of worms. The worm wraps these fibers about itself into a cocoon which serves to protect it during its period of change from the worm to the moth stage. Each fiber consists of two filaments surrounded and cemented together by a gum-like covering.

The Chinese were the first to discover that cocoons could be boiled in water and the fibers unwound and used for making cloth. They found that a species of worm which lived on mulberry leaves produced especially satisfactory fibers, while another, living on oak leaves was also usable.

The cultivation of the mulberry silkworm began almost three thousand years before Christ. The first home of the industry was China. The idea of cultivating silkworms is credited to the Empress Si-ling, who lived



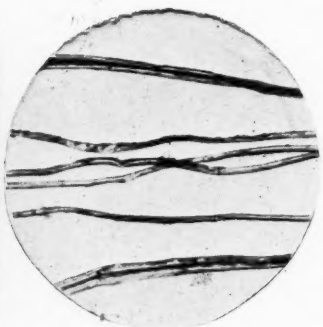
MICROPHOTOGRAPH OF TUSSAH SILK FIBERS. THESE FIBERS ARE TAKEN FROM THE COCOONS OF "WILD" SILK WORMS, THIS PARTICULAR VARIETY FEEDING UPON OAK LEAVES. PONGEE SILK IS OF THIS ORIGIN



MULBERRY SILK WORM MOTHS LAYING EGGS ON A PAPER ESPECIALLY PREPARED FOR THE PURPOSE BY THE CHINESE SERICULTURIST

about 2700 B.C. Si-ling was the wife of Emperor Hoang-Ti, whose reign is said to mark the invention in China of wagons, bows, and bells. Since this famous empress wanted enough silk produced for the use of all of the people over whom her august husband reigned, she thought of the plan of feeding and caring for silkworms. She herself carried on silkworm

SILK WORMS IN A FEEDING BASKET



MICROPHOTOGRAPH OF A MULBERRY SILK FIBER

culture and silk spinning, so as to set a good example for the women of her empire. From the time of her reign, the cultivation of the mulberry silkworm became a common thing in China.

The cultivation of the silkworm likewise began in India at a very early date. Both of these oriental countries guarded the secret of the way in which the silk fiber was produced. It was not until hundreds of years after the cultivation of the silkworm had begun in these countries that other parts of the world knew where silk came from. Great caravans laden with raw and woven silk regularly left these for other Asiatic countries, but the source of the fiber was a mystery. The Persians bought most of the Chinese and Indian silk. They bought some of the product raw, and converted it into cloth of their own design; and they also sold both this and finished cloth, which they had bought ready woven, to the Greeks and Romans at tremendous profits.

An Empress Begs for a Silk Dress.—When silk was first introduced into Europe, it sold for its own weight in gold. Heliogabalus, a Roman emperor from 218 to 222 A.D., was severely criticized by his subjects because of the hopeless extravagance which he displayed when he bought for himself a garment made wholly of silk. Aurelian, the Roman emperor who came to the throne in 270 A.D., is quoted as refusing to buy a silk dress for his wife in these words: "The gods forbid that I should purchase silk at the price of its weight in gold."

The Secret of Silk Revealed.—The Persians continued to sell silk to the Greeks and Romans until the sixth century A.D. It was during the reign of Justinian, which ended 565 A.D., that a war with Persia put an end to this trade. Justinian, who was emperor of the Eastern Roman Empire, with a capital at Constantinople, realized that the buying of silk from the Persians was taking vast sums of gold from his realm into the realm of his enemy. He therefore passed a decree which put an end to this trade. But his countrymen were dissatisfied with this state of affairs. Consequently, he paid two monks, who reported that they had found out the origin of silk while they were in the orient, to go to India and smuggle out some silkworm eggs. Because of climatic conditions, however, only the southern part of Europe was found suitable for this industry. Ever since this time the quantity of silk produced has always been behind the demand for it.

Legal Limitations on Use of Silk.—Price and quantity available are not the only factors which have limited the amount of silk which people could use in times past. In England, laws were passed during the Middle Ages which forbade the use of this fiber as well as of finery, in general, to people in certain walks of life. This was apparently done for the purpose of keeping people in their proper social grooves.

Various English statutes attempting to regulate dress were enacted between 1336 and 1554. The first of these laws, passed in 1336 under Edward the Third, restricted the use of fur to members of the royal family, prelates, earls, barons, knights, and people of the Holy Church.

A number of laws[1] were passed during the next century restricting the use of cloth of gold, ermine, embroideries, precious stones, silk, purple, and gold and silver ornaments. The amount of money which people of various incomes could expend upon clothing, and in some cases, even, the number of yards of material which people in certain stations could use was carefully specified.

A few years later, these laws were made even more rigid. Handicrafters and yeomen, together with their wives and children, were, according to this law, forbidden to wear "cloth of silk, nor silver, nor girdle, knife, button, ring, garter. . . . . ribband, chain, nor no such other things of gold nor of silver, nor no manner of apparel embroidered, aimeled (enamelled) nor of silk in no way." They were further restricted in the fur which they could use in their garments to lamb, cony, cat, and fox. In this same law, "carters, drivers of the plough, oxherds, cowherds, shepherds and all other keepers of beasts, threshers of corn, and all manner of people of the estate of a groom attending to husbandry and all other people that have not 40 shillings of goods" were restricted to plain woolen garments of 12 pence.

After a succession of clothing laws which were tried and repealed, Henry VIII made another attempt to regulate dress in 1532 and 1533. Among other things, he decreed that women whose husbands could not afford to maintain a light horse for the King's service had no business with gowns or petticoats of silk, French hoods, or bonnets of velvet. Mary further added to the statute books by fining a man whose income was under 20 pounds a year for displaying silk on his cap or shoe, and women of the station of nurse maid for wearing silken ribbons. The last of the English laws imposing restrictions in dress was passed in 1554 during the reign of Philip and Mary.

These restrictions had the effect of causing increased longings for the forbidden fabrics. When they were later repealed therefore there remained but one limitation on the general use of silk—that of cost.

[1] See "Old English Laws Regulating Dress," Silvia A. Miller, *J. Home Economics*, Feb., **1928.**

Importance of Using Fresh Explosives. To promote efficiency in the use of "permissible" explosives, coal-mine operators are urged by Dr. Charles E. Munro, Chief of the Explosives Division, United States Bureau of Mines, to make use of only freshly made explosives in their blasting operations. To make sure of this being done, it is recommended that they purchase permissibles, or have deliveries of them made in such quantities only as can be consumed in blasting in a reasonably short time, say three months, and that permissibles be so stored in magazines that all of the older explosives in a magazine shall be checked out and used before any part of a fresh consignment in the magazine is issued. It is obvious that substances such as explosives, which are of a complex nature, and easily affected by a variety of causes, will not long remain definitely unchanged.—*Chem. Age*, **19**, 454 (Nov. 17, 1928).

GENERAL SCIENCE IN THE FIFTIES*

JOHN H. GARDNER, WASHINGTON UNIVERSITY, ST. LOUIS, MISSOURI

While wandering through the lower end of Baltimore, I found in an old furniture store a copy of a general science textbook written in 1851, and, if one may judge by statements on the back of the title page, used in the public schools of Philadelphia and Brooklyn. The book is a late representative of the scientific catechisms which had been popular a half century and more before, and which are still to be found in old book stores. Wondering what kind of science was taught to our ancestors in those days, I slowly turned the pages and found what follows.

Question: Why does salt preserve meat?

Answer: Salt is composed of chlorine and sodium; the chlorine of the salt takes up the hydrogen of the meat as it is given off, and prevents the offensive taste and smell of decay.

Q: What is the best treatment for one who has swallowed prussic acid?

A: Apply diluted ammonia to the nostrils, and let a stream of cold water from a pitcher fall from some height on the region of the spine. Electrical shocks are said to be very beneficial also.

Q: Why does chloride of lime fumigate a sick room?

A: Because it absorbs the hydrogen of the stale air, and by this means removes both the offensive smell and the infection of a sick room.

Q: Why does India rubber erase pencil marks from paper?

A: Because India rubber contains a very large quantity of carbon; blacklead is carbon and iron. Now the carbon of the India-rubber has so great an attraction for the blacklead, that it takes up the loose traces of it left on paper by the pencil.

Q: When wine is spilled on a tablecloth, etc., why do persons generally cover the part immediately with salt?

A: Because salt is a compound of chlorine and sodium; and the chlorine of the salt acts as a bleaching powder.

Q: If a silver spoon, which has been tarnished by an egg, be rubbed with a little salt, why will the tarnish disappear?

A: The tarnish in this case is sulfuret of silver, produced by the sulfur of the egg combining with the silver spoon. Salt acts upon this sulfuret of silver, thus the sodium of the salt combines with the sulfur, and produces sulfate of soda. The sulfur being thus taken away from the silver, the tarnish disappears.

* Based upon a talk given at the meeting of the St. Louis Professional chapter, October 8, 1928. Questions and answers from *Familiar Science*, by R. E. Peterson, member of the Academy of Natural Sciences, Philadelphia, published in Philadelphia, 1852.

Reprinted from *The Hexagon of Alpha Chi Sigma*, **19**, 102–4 (November, 1928).

Q: Why are the ill-clad also instinctively averse to cleanliness?

A: Because dirt is warm (thus pigs, who love warmth, are fond of dirt). To those, therefore, who are very ill-clad, the warmth of dirt is agreeable.

Q: Why are the ill-fed instinctively averse to cleanliness?

A: Because cleanliness increases hunger, which they cannot allay by food.

Q: Why is yeast used in brewing?

A: Because it consists of a substance called gluten, undergoing putrefaction; in which state it possesses the peculiar property of exciting fermentation. If the gluten were not in a putrefying state, it could not produce fermentation.

Q: Why is yeast needful in order to make malt into beer?

A: Because the presence of a putrefying body containing nitrogen is essential in order to convert sugar into alcohol.

FEEDING IODINE TO SHEEP*

Research often succeeds in devious ways in disclosing results far removed from its original intention and object. At the time when an American chemist was engaged in isolating from the glands of sheep that organic compound called thyroxin, a constituent of the thyroid gland, he found that different sheep possessed varying amounts. Also those sheep that possessed large quantities of thyroxin in the thyroid gland were heavy wool growers; the others were scrawny and no good for wool. The answer then was immediate. Physiologists have known for years that the thyroid gland regulates bodily and mental processes, metabolic rates, rates of chemical combination and productivity in the body, and how these could be stimulated. So the result of this research was that the sheep in Montana were fed iodine. Increased activity of the thyroid gland resulted and they became valuable wool growers.

In direct relation to this is the necessity for its use in the human diet as a preventative of goiter. It is conservatively estimated that as high as 50 per cent of the school population in the northern half of the United States have incipient goiter, resulting from an abnormal condition of the thyroid gland. In regions of iodine deficiency artificial methods of supply must be provided; by iodization of public water supplies as is done in Rochester, N. Y., and Minneapolis; the use of iodized table salt as is enforced by law in the State of Michigan; the use of tablets or flour prepared from the iodine-rich extract of marine algae; and the inclusion in the diet of seafoods such as oysters and bluefish which contain appreciable amounts of iodine.

* From the *Industrial Bulletin* of Arthur D. Little, Inc., April, 1928.

Correspondence

COMMERCIAL MATERIAL FOR SCIENCE CLASSES*

We learn that in your columns you carry a list of organizations that furnish to schools an exhibit of their material, and that the Duriron Company is among those who do this.

We receive numerous requests from schools for such exhibits, and in as much as our product does not lend itself to the furnishing of a school exhibit—at least without furnishing one that would be a matter of serious expense to us—we will ask that you withdraw our name from this list.

While we have in the past acknowledged these requests, and have sent literature on Duriron, we feel that this has not been what has been wanted or expected, and we believe that you will be glad to correct your records in this matter by omitting our name in future issues of your journal.

Very truly,

THE DURIRON COMPANY, INC.,
H. R. DANIELS

DAYTON, OHIO

* See abstracts from *Science Classroom* (Sept., 1928), THIS JOURNAL, **5**, 1350 (Oct., 1928); **6**, 158 (Jan., 1929).

EUROPEAN AND AMERICAN METHODS IN EDUCATION

Dr. Muhleman's comments on my discussion in the November issue of THIS JOURNAL of his article on "European and American Methods of Education" call for further remark.

In order to take as a unit the period after high school, I purposely did not make the usual distinction between college and graduate school. Only thus is it possible to compare the systems. Besides, it is natural to consider students of the same age in both continents.

The statement that "no American *college*[1] or university offers high-school courses in English, French, German, chemistry, physics, and mathematics" will depend upon one's concept of a high-school course. What I have seen taught in American colleges is equivalent to European high-school courses.

Without any depreciation of the large amount of splendid work which is done in American graduate schools, it cannot be denied that only a rela-

[1] The italics are mine.

tively small number of the students who pass their first examination (B.Sc., B.A.) enter the higher training courses.

That conditions in Europe should be intolerable and that "European universities are long on theory but short on practice" may be considered as a personal opinion.

Accordingly, the statements and especially the conclusions in my first letter are unchanged. The purpose of my remarks was only to oppose views which, in the light of my experience, differ too much from reality.

This correspondence may show the reader who is weighing the subject for himself how difficult it is to form a correct concept of the two systems of education.

J. RINSE

OVERVEEN, HOLLAND

THE CORRELATION OF HIGH-SCHOOL CHEMISTRY WITH FIRST-YEAR COLLEGE CHEMISTRY—A CORRECTION

In my article on the above subject (THIS JOURNAL, **5**, 1627–33 (Dec., 1928)), Dr. Meldrum has pointed out a misprint in the quotation from his questionnaire regarding analytical work. I have consulted the blank returned by Dr. Meldrum and find that instead of "*quantitative* analysis," as printed on page 1631, under Haverford College, of this article the reading should be "*qualitative* analysis." I regret to have misread the abbreviated form in which this appeared in the blank.

LOUIS W. MATTERN

MCKINLEY HIGH SCHOOL,
Washington, D. C.

How to Pronounce Laboratory. Hearing well-educated English chemists repeatedly saying "la-bor'-a-to-ry," in which they separated the "bor" and then bore down on it, we thought maybe we were wrong.

Here is what the authorities have to say on the subject.

The accent is placed on the first syllable by:

1. Century Dictionary and Cyclopedia
2. Webster's Dictionary
3. New Standard Dictionary
4. Murray Oxford Dictionary

March's Thesaurus Dictionary places a major accent on the first syllable "lab" and a minor accent on the fourth syllable "to."

H. M. Winton, an English chemist, says that the Englishman's pronunciation of the word "*laboratory*" is wrong.

Authorities agree that this word is properly pronounced in five syllables divided as follows: *lab'-ō-ra-tō-ry*.

If we do not contract the word to four syllables—keep the accent on the first syllable, "lab"—pronounce the second syllable "o" (not "or")—do not slur the other three syllables—then we pronounce the word "laboratory" with authority.

If usage is the controlling factor in pronouncing this word—apply it to both sides and we end where we started.—*Laboratory*, **1**, No. 5, 68 (1928).

Chemical Digest

NATION-WIDE EXPERIMENT GRADES VALUE OF FILMS IN CLASSROOM TEACHING

Marked superiority of class work done by children taught with films over that of children taught by other classroom methods has been demonstrated by the formal completion of the most extensive experiment ever undertaken in education. A 33 per cent gain in geography and a 15 per cent gain in general science were scored by approximately 5500 children, taught with specially prepared films, over 5500 taught the same subject material without the aid of motion pictures, in a trial in public schools in twelve widely scattered cities, directed by Dr. Ben D. Wood of Columbia University and Dr. Frank N. Freeman of the University of Chicago. At the middle of October the two educators finished their 50,000 word report on the experiment, which was conducted over a period of ten weeks last spring.

Films Would Reduce Failures

If properly planned classroom films can raise pupils' marks by an average of 24 per cent as in this experiment, the report indicated, many failures will be turned into passing marks, since the great majority of failures are by less than 24 per cent. Thus the time required for repeating courses will be saved in many children's education, and large cost will be saved to municipalities. The average expense of keeping a child in school for a year is $100, which in Chicago, for instance, where there are 30,000 failures a year, would mean a saving of $3,000,000 a year if failures could be completely eliminated.

The experiment, representing the first time a nation-wide investigation has been made into the controversial question of the value of films in classroom teaching, was sponsored by the Eastman Kodak Company, which, as the result of the preliminary findings of Dr. Wood and Dr. Freeman last spring, established a $1,000,000 subsidiary corporation, Eastman Teaching Films, Incorporated, to prepare educational films for use from the primary grades up through graduate technical school work. The earlier report of Dr. Wood and Dr. Freeman said:

> We are making a preliminary report at this time because we believe that enough evidence is in to warrant a continuance of production of classroom films and because a delay in production until after the complete report is prepared would seriously interrupt the preparation of a film program for the schools.

107,870 Test Papers Written

The superiority of the class work done by children taught with these special films was determined by Dr. Wood and Dr. Freeman on the basis of 107,870 test papers written by the 11,000 children before and after the ten weeks of the experiment and periodically during the course of it. Because of the impossible task of properly grading so many papers, a scientific cross-section of 13,341 were read and marked. The application to the results of various methods of cross-checking showed this to be a fair procedure.

Both the classes taught with films and those taught without films used the same "study guides," according to the educators' report, and were given identical tests. The questions asked on the tests were based on the material contained in the guides studied by both groups and were so framed that they could be answered by the children who had not seen the films as well as by children taught with the films.

Prior to the experiment, all of the 11,000 children were given intelligence tests and tests of knowledge of the subjects to be studied. The final comprehensive tests in geography and general science contained half the questions of the initial tests, thus affording a direct measurement of gain in grasp of the subject.

To insure that, if the experiment should result in an indication of the superiority of motion pictures for teaching, no part of the results might be attributable to superior intelligence or qualifications on the part of the film-taught group, the school authorities in the twelve cities coöperated with the investigators by designating for the two groups in the experiment classes of children as nearly equal as possible. The preliminary tests actually showed, for the children who were to be taught with the aid of the films, a handicap in intelligence and in previous knowledge of the subjects. Similarly, an attempt was made to select teachers for the two groups as equal as possible in pedagogical ability.

The experiment was a regular part of classroom work. The films used were of the 16 mm. "amateur standard" size and were of "safety" material so that they could be projected in the classrooms without the use of projection booths. The report said:

> In this experiment, we have studied the films not as a panacea to be substituted for present instrumentalities of the schools, nor as a means to revolutionize the aims of education, but as an addition to the present pedagogical devices which may help in the attainment of currently accepted goals.

Relate Lessons to Experiences

In addition to the final advantage that the written tests showed for the film-taught children, reports from the teachers who used films in teach-

ing their classes and from school officers showed that a large majority believed the use of classroom films to have been

> . . . . more effective in arousing and sustaining the children's interest, in improving the quantity and quality of their reading, in stimulating their self-activities and originality, in developing their desire and ability to discuss subjects and to write about them, in increasing the richness, accuracy, and meaningfulness of experience and imagery, and in aiding them to correlate features of the lessons with personal experiences and community conditions.

The films used in geography teaching were:

> "New England Fisheries," "Wisconsin Dairies," "Wheat," "Wheat to Bread," "Cattle," "Corn," "Cotton," "Irrigation," "Bituminous Coal," and "Iron Ore to Pig Iron."

Those in general science were:

> "Hot Air Heating," "Atmospheric Pressure," "Compressed Air," "The Water Cycle," "Water Supply," "Purifying Water," "Limestone and Marble," "Sand and Clay," "Reforestation," and "Planting and Care of Trees."

These films had been made particularly for the experiment by the Eastman Kodak Company under the direction of Dr. Thomas E. Finegan, formerly Deputy Commissioner of Education in New York State and Superintendent of Public Instruction in Pennsylvania, who since the experiment has become president and general manager of Eastman Teaching Films. Practical teachers of long experience and known achievement were employed to prepare the material for the films, and the motion pictures were correlated with the standard courses of study in use in the schools of the country in the subjects taught under the experiment.

The twelve cities that participated in the experiment were:

> Rochester, New York; New York City; Chicago, Illinois; Detroit, Michigan; Newton, Massachusetts; Atlanta, Georgia; Winston-Salem, North Carolina; Lincoln, Nebraska; Kansas City, Missouri; Denver, Colorado; Oakland, California; and San Diego, California.

This large-scale experiment had the approval of a committee of the National Education Association, which urged the teachers of the country to coöperate whole-heartedly in the enterprise. The number of the teachers engaged in the experiment in the twelve cities was 232.

Films Especially Planned

Previous experiments in the value of classroom films have involved only about one-tenth of the film footage concerned in this experiment, and never before has a film experiment covered any large number of children or been a regular part of classroom work. In this experiment motion pictures were used in the classrooms in such a way as to avoid any sugges-

tion of a special or extra-curricular venture. Each series of films—geography and general science—was planned definitely for use in a particular grade. About two-thirds of the children participating in the experiment were in the elementary grades and one-third was in junior high school.

The report states:

With very few exceptions, the requirement was laid down that the experimental and control classes should be in different schools so as to prevent communication between either teachers or pupils of the parallel groups; but the schools so selected in each city were similar in general character, drawing their pupils from the same type of social background.

The present study had the decided advantage that the films used were produced especially for the investigation. Many so-called educational moving pictures are simply assembled from materials already in existence. The present series was produced, almost without exception, from the ground up. Before the photographs were taken, scenarios were carefully worked out and criticized and continuities were made from these scenarios.

The films used in the recent experiment were predominantly devoted to material essentially characterized by motion of one sort or another. The films are not entertainment films, though all who have used them find them exceedingly interesting. The films provoke many insistent questions in the minds of pupils, but do not destroy the educational value of these questions by answering them immediately in an authoritative manner. They rather stimulate closer observation and hold the questions in mind for a sufficiently long consideration to arrive at answers which the pupil himself thinks out. Titles are reduced to a minimum. The films tell no story and present no drama other than that which adheres to motion pictures of concrete things, places, and actions.

In theatrical films we have a self-contained and complete unit, with a definite beginning and a still more definite and satisfying ending, which tends to discourage further thought on the part of the audience. The classroom films with which we are here concerned are not each a self-contained unit carrying its own story which the pupil is to receive passively, and least of all have these films stories with definite and satisfying endings. On the contrary, each is an instrument which the teacher is to use, and not a substitute for the teacher, textbooks, maps, drawings, or any of the other time-honored instrumentalities of the classroom.

The films are intended to leave the pupils at the end with so many insistent questions in mind and with so many concrete and detailed impressions that the end of the picture will be, in effect, the beginning of increasingly satisfying efforts on the part of each pupil to interpret his own experiences and answer his own questions.

Two Types of Tests

The children who participated were subjected to two kinds of tests. During the first week of the experiment, and before the first recitation took place, a 200-item "true-false" and "multiple-choice" test was administered to all. At the end of the experiment a similar test was given. The second class of test given was the traditional "old type" or essay form. These tests were given every two weeks, and each test covered the material of two topics.

The comprehensive tests and the topical tests were prepared respectively by the two authors of the report, Dr. Wood and Dr. Freeman, and, although they collaborated in preparing the tests, it was not until the results of the two series had been tabulated that the results were compared. The results resembled each other closely.

The purpose of the topical tests was—by giving the pupils somewhat greater freedom in organizing their answers and by requiring answers in some cases to be expressed in other than verbal terms—to measure the distinctive outcome of instruction by the use of films to a greater extent than was possible with the tests of the objective type.

A typical question was: "Tell what a cod fisherman does from the start to the finish of a fishing trip to the Grand Banks." Another one: "Explain why the Grand Banks is a good place for cod fishing." Another one: "Describe the smelting of iron ore, telling: (*a*) the materials that are put into the furnace, (*b*) how the furnace is heated, (*c*) how the iron is separated from other substances." Another type of question required the drawing of a map or a diagram.

The papers from the experimental and control groups were mixed together before they were scored, so that the scorers did not know from which group the paper they were marking came.

Purpose of Films Distinguished

In conclusion, the report of Dr. Wood and Dr. Freeman determined, basing judgment on the relative marks made by pupils in topical tests covering the various films, that:

Although teachers reported that the films stimulated reading and the relation of knowledge to personal experience, nevertheless films appear more effective in imparting the concrete aspects of the subject than knowledge of the more abstract facts and the ability to make explanations and generalizations. But when allowance is made for the fact that the experimental group had an initial handicap (as described earlier in this article), the experimental group is superior in answering the abstract type of question no less than in the other type of question.

But this difference in the relative attainments of the experimental and control groups is of broad significance and leads to a fundamental distinction. The first and most immediate aim of the pupil's education is to make him acquainted with the world about him. He first has to discover the characteristics of the concrete objects of the physical world. This education may be called immediate or direct education.

The second, a deeply important object, is to enable the pupil to derive from his direct experience general or abstract ideas and through reflection and reasoning to search for and acquire explanatory principles to illuminate his direct or concrete experience. This may be called the indirect phase of education. Both phases are important and neither one is complete without the other.

The foregoing analysis has shown that motion picture films contribute to both aspects of the child's education. It shows, however, that films contribute by a much larger amount to the direct than to the indirect aspect.

Superiority in direct experience should increase the effectiveness of the pupil's thinking, and our evidence shows conclusively that this result is attained.

No attempt should be made to distort the films from their natural purpose and to make them a means of teaching abstractions directly.

A disciplined mind and a cultivated heart are elements of power.—CALEB MILLS

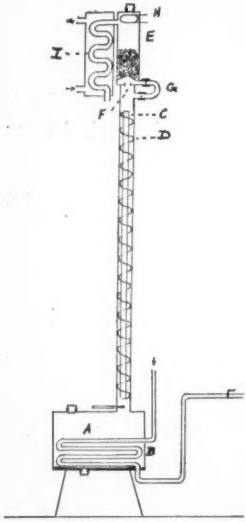
ABSTRACTS

TEACHING METHODS, AIDS, APPARATUS, AND SUGGESTIONS

Commercial Material for Science Classes. ANON. *Sci. Classroom*, **8**, 12 (Dec., 1928); **8**, 12 (Jan., 1929).—In THIS JOURNAL, **5**, 1350 (Oct., 1928) we printed an abstract under the above title from the Sept., 1928 issue of *Science Classroom*.

Corrections to that list have been published as follows: "The Duriron Co., Inc., Dayton, O., does not supply exhibit material for classes." (See Correspondence, THIS JOURNAL, **6**, 151 (Jan., 1929). "The Crucible Steel Co of America, 17 E. 42nd St., New York City, does not supply material for high-school chemistry classes." "Vacuum Oil Co., 61 Broadway, New York City, does not supply material for high-school chemistry classes."

Additions to Lists of Firms have been made as follows: Abbott Laboratories, North Chicago, Ill.; Aluminum Wares Association, 844 Rush St., Chicago, Ill.; American LaFrance and Foamite Corp., Turner St., Utica, N. Y.; Calumet Baking Powder Co., Chicago, Ill.; E. I du Pont de Nemours & Co., Wilmington, Del.; Merck and Co., 45 Park Place, New York, N. Y.; Rayon Institute, 250 Fifth Ave., New York, N. Y.; Standard Oil Co., of New York, 26 Broadway, New York, N. Y. M. W. G.



Dufton Distilling Column for Preparation of Absolute Alcohol. W. A. NOYES. *Ind. Eng. Chem.*, **20**, 1190–1 (Nov., 1928).—A simplified apparatus, using the Dufton distilling column, is described.

In explanation of the cut reproduced:

A—15-liter copper boiler for untreated alcohol
B—steam coil of galvanized iron pipe
C—brass tube closed at both ends
D—annealed copper rod, forming tightly-fitting spiral within the copper tube as shown
E—brass reservoir, containing anhydrous $CaCl_2$
F—brass tubing through which alcohol vapors enter *E*
G—U-tube, enabling inspection of $CaCl_2$ solution as it runs from reservoir
H—copper coil through which cold water runs slowly, causing the condensation of a small amount of alcohol, and controlling the downward flow of the solution
I—worm for condensation of treated alcohol

Directions for operation of apparatus are included. From 10,000 cc. charge, 9500 cc. of 99% alcohol are obtained. By redistillation, it is claimed that 99.7% alcohol may be obtained. M. W. G.

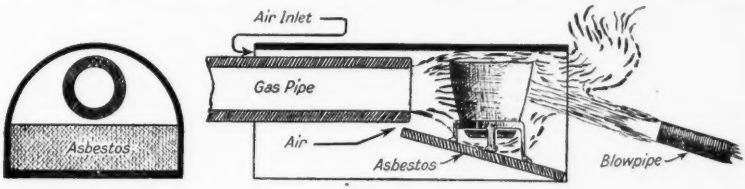
Reflex Furnace Reduction of Oxides. R. SAXON. *Chem. Age, Metallurgical Section*, **19**, 27 (Oct. 6, 1928).—"In the ordinary way, using a cast-iron pipe instead of combustion glass tubing, a temperature high enough to melt brass may be attained using the blowpipe. When the whole pipe gets sufficiently hot, a silica boat may be introduced containing the oxide, and coal gas sent through. This heated gas readily reduces copper, cobalt, nickel, iron, lead, and bismuth, and, together with carbon, antimony. The best form of carbon is that in paraffin wax. A boat of this in the end of the pipe where the gas enters distils by heat and greatly assists the coal gas. Some, of course, is mixed with the oxide.

"For the more refractory metals, arrangements have been used to render the flame issuing from the pipe a Bunsen. Use is made of a long hood bent U shape, projecting beyond the end of the pipe, and lifted from it by coiled wire netting. A floor of asbestos is fitted in the end, reaching to the pipe end. This slopes to allow the play of the blowpipe under a crucible held so that its top is played upon by the flame from the pipe, while the underside may be reached by the blowpipe flame. The use of the blowpipe takes away the luminosity from the pipe flame, and its heat is reflected from the arched top into the crucible itself, without the possibility of air entering. There is no necessity to use a lid.

"Two blowpipes may be used, one on either side of the crucible, the coal-gas flame

playing between them. Such an arrangement makes it impossible to use baked clay crucibles, which expand and crack. Calcined clay, thin ones, are best, but their pores must be closed by roasting them after coating with resin, shellac, or aluminum paint. This fills some of their pores with carbon, which does not readily burn out. The aluminum may assist reduction if not first of all oxidized by roasting with or without niter. The latter must be used sparingly, or the potash will dissolve out the aluminum oxide. However, when carefully introduced into the pores of calcined clay, there is no more serviceable crucible.

"Manganese may be reduced by paraffin wax, but not easily. Chromium, vanadium, aluminum, etc., successfully resist reduction. Magnesium powder reduces manganese and chromium with comparative ease. The best flux with all these reductions is common salt with a little potassium chloride and hydrate. More than about 5 per cent admixture of these does not assist fusion. As "seasoning," however, they do materially assist. For preliminary experiments thin calcined smoking clays are better than any other form of crucible. The stem forms an outlet for distilling wax and gas and finally closes up. The caustic potash does not attack it as it does silica, and one is



End View. Longitudinal Section.

not afraid of giving it generous heat on account of its cost. Thick ones invariably crack under the heat.

"A determining factor in a number of reductions has been the tendency of lime to form calcium carbonate, even under roasting conditions. This was the lever used formerly to reduce potassium from the carbonate. For this reason crushed calcium carbide is employed in reducing manganese, chromium, zinc, magnesium, and aluminum from their oxides, and cadmium, iron, and copper from the sulfides. The manganese decomposes water rapidly. Taking aluminum as an example, the following reaction takes place—

$$3CaC_2 + 3Al_2O_3 = 3CaO + 6CO + 6Al,$$

and although the carbonate does not appear here, it does with lower temperatures. The carbon monoxide can be seen burning at the mouthpiece end of the pipe. The whole is put into water to get rid of superfluous carbide and lime. When thrown into acid sufficient to deal with the undecomposed oxide, effervescence, or the lack of it, is an indication of probable success or decided failure as the case may be. On a larger scale the gas may be identified as hydrogen. If the carbide and wax be roasted together no carbonate results, nor can effervescence be obtained with acid. The presence of bubbles of gas, therefore, is a good suggestion of the presence of the metal."

The arrangement of the apparatus is shown in the accompanying diagram.

M. W. G.

A Practical Apparatus for Determining Molecular Weights by the Boiling-Point Method. H. RUPE AND N. WASSILIEFF. *Helv. Chim. Acta*, **11**, 713–6 (1928); *The Analyst*, **53**, 510–1 (Sept., 1928).—The apparatus described is a modification of that of Washburn and Read (*J. Am. Chem. Soc.*, **41**, 729–31 (May, 1919).—"The boiling vessel consists of a test tube of good quality, about 190 mm. long and 31–32 mm. wide, and having sealed to it, somewhat below the mouth, an inner, open-ended jacket, *A*, 70 mm. in length, the space between the two tubes being 1.5–2 mm. Just below the top of the inner jacket is a side tube, *B*, connected with a small condenser, *C*, by a ground joint. The most important part of the apparatus is a tube *D* (Figure 2), 130 mm. high, funnel shaped at the base, standing on three feet, and branched at the top to form three tubes with somewhat narrow orifices. The short thermometer, *E*, such as is used with the Landsberger apparatus, reads to 0.05°C., and is held by a cork so that its bulb is between the three branch tubes. When the liquid boils, solvent (or solution) and vapor impinge on the thermometer bulb, and the vapor partially condenses. For acetone, the

dimensions of the boiling tube are as shown in Figure 2; for benzene or water, the width is 5.1 mm. below and 3.9 mm. above; and for chloroform, 3.9 mm. below and 2 mm. above. Retardation of the boiling is prevented by a few small fragments of porous tile, but with water a few scraps of platinum are required. Heating is effected by a Bunsen burner with the tube removed, the flame, protected by a cylinder of asbestos paper, being about 10 cm. below the apparatus. With acetone or chloroform, a deter-

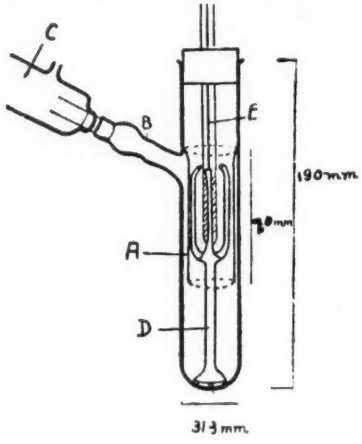


Figure 1

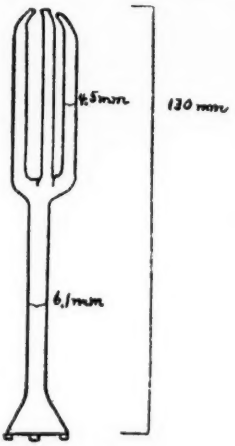


Figure 2

mination may frequently be completed in 20 minutes, but with water about an hour is required. Molecular weights between 100 and 200 are determinable with considerably less than the allowable 10 per cent error, the only exception observed being that of *p*-nitrophenol in acetone, for which values of about 123.5 were repeatedly found, in place of 139.05." M. W. G.

Toy Balloons and Filtration. JOHN W. GARRETT AND C. D. HURD. *Ind. Eng. Chem.*, **20,** 1130 (Nov., 1928).—"Rubber dams as aids in pressure filtration in the laboratory have been recommended by Gortner [*J. Am. Chem. Soc.*, **36,** 1967 (1914)], Clarke [THIS JOURNAL, **4,** 1012 (Aug., 1927)], and perhaps others. This prevents the caking and cracking of the precipitate as the solvent is withdrawn. A modification of this plan which is somewhat simpler is to employ an inflated toy rubber balloon in place of the sheet rubber. The balloon has certain definite advantages over the rubber dam. In the first place, it sits on the Buchner funnel securely and needs no mechanical device to hold it in place. Furthermore, there are no "wrinkles" to be smoothed out, since the supple spherical contour of the balloon conforms perfectly to the edges of the funnel. For the usual laboratory Buchner funnels, an ordinary toy balloon is of convenient size when properly inflated. It is placed on top of the funnel after most of the solvent has been removed, but while the precipitate is still in pasty condition." M. W. G.

A Continuous Extractor. DOUGLAS HENVILLE. *The Analyst*, **53,** 380–2 (July, 1928).—"This apparatus was devised for the rapid extraction of large quantities (50 g.) of materials from which the oil or other soluble substance can be easily extracted, such as the extraction of phenols from carbolic powders having a siliceous base.

"The bottom of the extractor is packed with cotton wool or other suitable filtering medium. It is preferable to use one complete piece of cotton wool, as, if several layers be used, air is enclosed between them and this may rise during the extraction and disturb the packing. A weighed quantity of material is introduced, and the extractor attached to a reflux condenser. A flask containing the solvent is fitted to the stem of the extractor. The flask must not contain so much solvent that the extractor could fill up and overflow through the large side tube into the flask. The solvent is distilled into the extractor in the usual way.

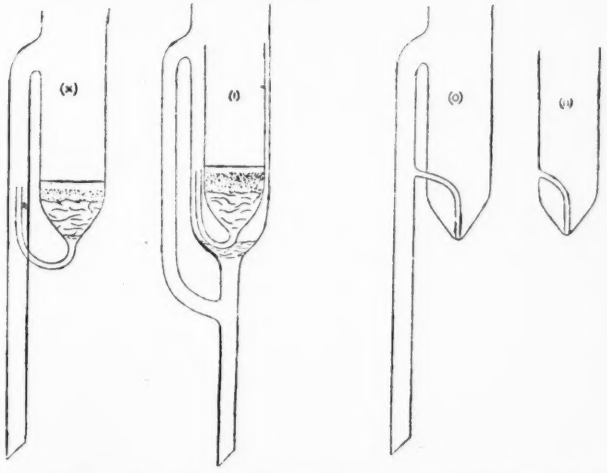
"Where the extract is heavy, as in the case of the extraction of phenols, etc., or where a considerable depth of a fine powder is being extracted, a certain amount of 'head' is at first necessary to drive the extract over and distillation is continued until a rapid flow of solvent is obtained; in addition, air bubbles have a retarding effect, but these gradually disperse.

"A large margin of space to allow for the formation of this 'head' has been allowed in the design of the apparatus. The 5 g. size extractor has also been made of such a diameter that the 3 to 5 g. quantities usually taken for extraction form a shallow layer and do not obstruct the passage of the solvent."

The drawing (X) shows the complete extractor and the drawing (O) shows another type in which the small tube is placed inside.

The apparatus has the following advantages:

(1) Neither thimbles nor filter paper packets are necessary (they can be used if required).
(2) The substance to be extracted is always totally immersed in the solvent.
(3) The "pressure" is directly on the solvent in contact with the material, and the extracting liquid is always in motion. (In the Soxhlet extractor the "pull" acts on the liquid outside the thimble. After each "siphoning over" a little more extract-containing solvent drains from the thimble into the bottom, and the extractor has to be filled again before "siphoning" takes place. This continues until extraction is complete.)



(4) There is a continuous and rapid flow of solvent. The rate of flow is, of course, dependent on the rate of distillation.
(5) If the apparatus be left to "stand over night," the substance remains totally immersed, and when the extractor is started again the first few ml. of solvent from the condenser cause circulation to continue.
(6) As soon as the solvent is circulating easily, only a few ml. are necessary in the flask to continue the extraction.
(7) The contents of the extractor are visible.

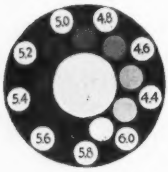
"The extractor may be used for the extraction of substances which require no filtering medium, and cakes, etc., in which some form of filter is necessary.

"Using asbestos as a filtering medium, cocoa has been successfully extracted without any of the fine powder passing through into the flask.

"On the same principle (1) and (11) are glass thimbles which are placed in the container shown. The thimble may rest on cotton wool, which supplies a further filtering medium, or may rest directly on the glass, when the hot vapor will pass up and round the thimble. Except for special purposes, when these thimbles might be required, the complete extractor (X) is simpler and more satisfactory in use." M. W. G.

Determinations of pH Simplified by Permanent Color Standards. *Laboratory*, **1**, No. 5, 74–5 (1928).—The new glass standard pH indicator uses standards which will not change color. Its standards are the proper colors and have been checked by the potentiometer method; these colors cannot change with time or use.

Aside from ease of operation, the permanent glass standard pH indicator is inexpensive.



THE CONVENIENT DISK WITH RANGE OF COLOR STANDARDS

The following principle underlies this pH indicator:

"Light from a source of illumination passes through a diffusion screen and is split into two rays—one passes through a cell containing distilled water and then through the standard color glass. The other ray passes through the cell containing the solution, the pH of which is to be determined, and to which several drops of the indicator have been added. The two fields are then brought into juxtaposition by a prism and are viewed through the monocular eyepiece.

"The disk holding the standard color glasses is rotated until a color match is obtained at the eyepiece, and the pH of the solution is that corresponding to the pH value of the glass in view. This is read through a small window in the front of the instrument.

"The glass cells employed are rectangular in cross-section and have optically plane-parallel sides. This eliminates the varying color intensities occurring when test tubes or cylindrical cells are employed, in which case the depth of liquid is greater at the center.

"The pH standards of reference are interchangeable discs, each containing 8 to 10 circular standard color glasses. These disks are inserted in a slot in the right side of the housing and rotate on a shallow spud so that the color glasses successively rotate into the field of view.

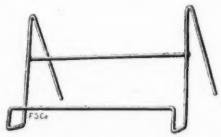
"Each disk covers a definite range of pH units as follows:

Indicator	pH Range In Steps of 0.2 pH
Thymol blue, acid	1.2 to 2.8
Bromphenol blue	3.0 to 4.6
Methyl red	4.4 to 6.0
Bromthymol blue	6.0 to 7.6
Phenolphthalein	8.4 to 10.2
Alizarin yellow	10.2 to 11.6
Violet	12.0 to 13.6
Universal indicator	4.5 to 9.0
	The latter in steps of 0.5 pH

"The actual indicator solution which is added to the unknown solution comes already prepared for use so that it is only necessary for the operator to add 2 or 3 drops and, after shaking, compare with the standard color disks.

"To determine the pH of turbid or colored solutions, the distilled water cell is filled with the unknown solution, without indicator, while the other cell is filled with the unknown solution with the indicator." G. B. C.

A Laboratory Book Support. *Laboratory*, **1**, No. 5, 72 (1928).—A laboratory book support, suggested by M. G. Mellon of Purdue University, has been devised which holds the book open at the desired place and at the angle which enables it to be most conveniently read by one standing in a natural position in front of the work bench.



THE NEW LABORATORY BOOK RACK

"This is an extremely simple and inexpensive device made of tinned wire of heavy gage. It occupies a table space of but $4\frac{1}{2}$ by $8\frac{1}{2}$ inches which is less than one-half the space occupied by the usual textbook when opened.

"This new support holds the book open at any desired place without first breaking its backbone." G. B. C.

Visual Education in the Museum of Science and Industry. F. C. BROWN. *Educ. Screen*, **7**, 181–2 (Oct., 1928).—A museum exhibit should: first, attract the visitor; and second, should by its assembly retain the visitor's attention until he is made conscious of its educational value.

Exhibits are classed as of: *First order* if they not only attract but impel the one attracted to think of them "long after he has seen them;" *second order* of merit if operated

and explained by a guide; *third order* if a model, either enlarged or reduced in size as the case may demand, is displayed, provided it is not incased in glass; *low order* of merit if exhibits consist merely of aggregations of products, maps, charts or anything within glass cases.

Museums recognize that they must sacrifice advantages which come from "doing things which have to be done" and in their stead try to attract patrons "somewhat in competition with library, theater, and recreation grounds." B. C. H.

The Status and Trends of Visual Aids in Science. L. A. ASTELL. *Educ. Screen*, **7**, 183–4 (Oct., 1928).—Some needs for improving the availability as well as quality of stereoptican slide and film are listed. Among them are: improved film exchange service with educational needs more fully catered to; organized and accessible data upon films obtainable for individual science subjects. Such data to include inflammability of film stock as well as quality of the pictures.

Film lists endorsed by authors for use in connection with their texts would be very helpful. Some authors are developing film strips as supplemental illustration material for use with their texts.

A staff member "trained in administration, supervision, and organization of visual aids" is advocated for even the smaller schools. B. C. H.

KEEPING UP WITH CHEMISTRY

Succinchlorimide. EDITORIAL. *Compressed Air Mag.*, **33**, 2592 (Nov., 1928).—This compound of succinic acid and chlorine is a sterilizing medium, put up in handy tablet form, for the purification of water for drinking purposes. This should prove of special benefit to campers, tourists, and soldiers in the field, and others who must often drink water not under sanitary control. A small tablet or two will sterilize enough water to fill a canteen. Succinchlorimide is the outcome of research of army chemists of the U. S. Army Medical School. E. R. W.

Spray-Gun Insulation. EDITORIAL. *Silicate P's & Q's*, **8**, 11 (Nov., 1928).—Houses of the future are to be insulated against loss of heat. Materials available include cork, wool, asbestos, infusorial earth, and solid bubbles of expanded silicate. The last has the advantage of being quickly applied especially if put on with a spray gun.

The spray gun idea has been utilized in applying cements in repairing hot coke ovens and for replacing refractory cements smoothly and economically. For applying insulation, shredded old newspapers are released from a nozzle along with the spray of adhesive silicate solution, which quickly sets and holds in place a firm layer of insulating material. B. C. H.

Fused Quartz Laboratory Apparatus Made by New Methods. *Laboratory*, **1**, No. 5, 69–71 (1928).—"The utilitarian value of a piece of fused quartz apparatus varies: *first*, with the purity of the quartz; *second*, with the absence of bubbles; *third*, with its uniformity.

"Water white crystals of quartz, containing less than two-tenths of one per cent impurities, are flaked off by a blow torch and those from the outer surface discarded. These particles are then washed in acids. Sand, 99% SiO_2, can be used, but it is not pure enough to make the best fused quartz.

"The quartz crystals are then placed in a graphite crucible which is, in turn, placed in a vacuum arc furnace where the temperature is raised to the melting point. During the fusion the pressure is kept as low as possible. The mass of fused quartz thus produced is clear and transparent and contains relatively few bubbles.

"The molten slag of fused quartz is then subjected to a very high pressure and practically all of the remaining bubbles are collapsed or reduced to microscopic size. Pressure is also employed to extrude the fused quartz into rods, tubes, etc."

Combustion tubes and crucibles are described in detail as to size, prices, and distinctive features. G. B. C.

Using Heat to Make Ice. EMILY ALLEN SAYRES. *Home Economist*, **6**, 284 (Oct., 1928).—From an evening's inspiration and a year's patient work two students, Baltzar Carl Von Patten and Carl George Munters of the Royal Institute of Technology in Stockholm, gathered together the theories they had learned in school and evolved a system for using heat to make ice. It follows in principle:—a gas flame heats a generator containing ammonia in water, causing ammonia vapor to rise. This vapor passes through a horizontal tube leading into a U-shaped tube where it is conditioned by pure liquid ammonia. From here the vapor passes through a water-cooled condenser where it is changed to a liquid. This liquid goes through a heat exchanger and up through an evaporator which is the freezing unit. In the evaporator the NH_3 gas is mixed with H_2 gas, to keep the pressure constant and eliminate the necessity for valves. The mixture

of NH_3 and H_2 being heavier than H_2 passes back through the heat exchanger to the absorber where the NH_3 is dissolved in water and this solution returns to the generator. The H_2 being released, rises in the absorber and passes back through the gas heat exchanger up to the evaporator where it is ready to be used once more. This system never needs a pump, motor, valves, nor has it any machinery to get out of order.

J. W. H.

A Substitute for Arsenic. S. MARCOVITCH. *Sci. Mo.*, **27**, 459–62 (Nov., 1928).—Although arsenic has long been the only practical insecticide, it now appears to have a strong rival in sodium fluosilicate. The latter is not only more toxic but can be used against certain types of insects that refuse to eat arsenicals. The irritating properties of the sodium fluosilicate cause them to rake their feet through their mouths to get the irritating stuff off. The toxic action is due to the precipitation of essential calcium from the tissues. It is obtained as a by-product in the treatment of phosphate rock, which usually contains about 3% of CaF_2 and some silica. G. W. S.

Carboloy—A New Tool Material. SAMUEL L. HOYT. *Gen. Elec. Rev.*, **13**, 585 (Nov., 1928).—See THIS JOURNAL, **5**, 1399–405 (Nov., 1928). E. L. M.

The Vitamin Content of Mung Bean Sprouts. CAREY D. MILLER AND DORIS B. HAIR. *J. Home Econ.*, **20**, 263–71 (1928).—The oriental population of Honolulu uses large quantities of sprouts of the mung bean (*Phaseolus mungo* or *P. aureus*). These sprouts have been found to be a fair source of Vitamin *A* and a good source of Vitamin *B* in both the raw and cooked state, and an excellent source of Vitamin *C* in the raw state and a good source in the cooked state. Using Sherman's unit basis, the sprouts have a Vitamin *A* value $^1/_{25}$ – $^1/_6$ that of lettuce and $^1/_{25}$ that of green peas; a Vitamin *B* value equal to lettuce, and $^1/_{10}$ that of raw green peas; a Vitamin *C* content (raw) equal to that of lemon, orange, or tomato juice. R. A. B.

The Calcium of Cheese. KATHARINE BLUNT AND EMMA SUMNER. *J. Home Econ.*, **20**, 587–90 (1928).—A sour milk cheese such as "cottage" cheese has been found to be a poor source of Ca as contrasted with a hard rennet cheese such as "Swiss" cheese. The latter contains 9–14 times as much Ca as the former. The casein of the milk is originally in the form of calcium caseinate. When this is acted upon by rennet, the new insoluble product, calcium para-caseinate, contains all the Ca. However, when acid acts upon the original calcium caseinate in milk, free casein is formed as curd and soluble calcium lactate remains in the whey. R. A. B.

Counting the Atoms and Electrons. L. F. CURTISS. *Sci. Mo.*, **27**, 398–409 (Nov., 1928).—The methods available for counting atoms or electrons are the scintillation method of Rutherford, the cloud-chamber method originated by C. T. R. Wilson, and the electrical counter devised by Geiger. A detailed description including drawings of the Geiger counter is given. It is composed essentially of a cylindrical metal tube closed at one end save for a small hole to permit alpha or beta particles to enter. An insulating stopper fits the other end and supports axially a finely sharpened platinum or steel needle. The walls of the counting chamber are charged with constant potential of from one to two thousand volts and the needle is connected to some sensitive detecting device such as a string electrometer or vacuum-tube amplifier. For each alpha particle that enters the chamber a record is made by the detector. A discussion is given of its applicability and of the nature of its action. G. W. S.

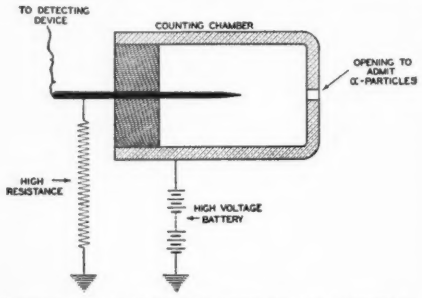


FIGURE 1.—A Diagram Showing the Essential Features of the Geiger Ion Counter.

The Production, Properties, and Uses of Zinc Oxide. I & II. *Chem. Age*, **19**, 433–4 (Nov. 10, 1928); 455 (Nov. 17, 1928).—A brief survey of the present commercially important compound—zinc oxide. M. W. G.

Cast Iron Is Looking Up. L. W. SPRING. *Chem. Bull.*, **15**, 322 (Nov., 1928).—The different types of cast iron are discussed including the "newcomer," pearlitic iron. This very desirable, strong, and tough material should raise the social standing of cast

iron in the field of iron and steel since it can replace, in many instances, the higher priced product which is more corrosive. E. L. M.

Glycerin and Its Substitutes in Industry. W. F. DARKE AND E. LEWIS. *Chem. & Ind.*, **47,** 1073–92 (Oct. 19, 1928).—A very complete review of the use of glycerin in industry. Among the many uses that are discussed in some detail are, edibles, medical and surgical uses, pharmaceuticals, plastics, resins, explosives, leather, paper, tobacco, and printing. Several flow sheets and diagrams are given. A valuable bibliography of over one hundred and thirty references is included. E. R. W.

Mohave Desert as a Source of Potash. R. G. SKERRETT. *Compressed Air Mag.*, **33,** 2427–33 (1928).—An illustrated article describing the development of the Searles Lake saline deposit in California. The ancient level of the lake was over 600 feet higher than the present level. Except during the rainy season the surface of the lake is covered with a salty crust capable of sustaining a motor car. This crust is almost pure NaCl. Below is a crystalline structure of an open cellular character which extends to a depth of approximately 70 feet. The pores of this "crystalline sponge" are filled with a dense brine which contains as minor constituents, KCl and borax. This brine is pumped from wells sunk in the surface of the lake and piped for four miles to the evaporators. One ton of brine holds 95 pounds of KCl and 30.2 pounds of anhydrous borax. The vacuum pans have to handle 21 tons of brine to produce 1 ton of potash and this ton of potash must be separated from 6 tons of other salts. The lake is estimated to hold 35 million tons of KCl—enough to meet our present domestic demand for 100 years. Only 80 thousand tons are being produced annually. The article includes a flow sheet of plant operations and a discussion of the solubility curves upon which the separations are based. (The abstractor wishes to call attention to a booklet describing the industry which is now being distributed by the American Potash and Chemical Corporation, 233 Broadway, New York City.) R. A. B.

Mining Gold at the Central Eureka in California. E. H. DICKENSON. *Compressed Air Mag.*, **33,** 2575–9 (Nov., 1928).—An illustrated article describing this interesting mine. The methods employed; the working conditions, and the earnings of the mine are discussed in some detail. E. R. W.

The Field of Photochemistry. FARRINGTON DANIELS. *Chem. Bull.*, **15,** 285–7 (Oct., 1928).—The essence of the chemistry involved in photochemical processes is said to be the displacement of an electron by a quantum from an inner position of stability to an outer one of lesser stability. The molecule containing the displaced electron is thus rendered active and so more capable of chemical action.

Einstein's equivalence law is accorded a place of prominence in theoretical photochemistry. It is said to apply only to initial and not to secondary processes which may obscure the primary reactions.

Two conditions essential for quantitative research in this subject require light that is: (1) monochromatic and (2) of measurable intensity.

The scope of photochemistry is suggested as inclusive of x-rays, ultra-violet rays, infra-red irradiation, as well as visible rays. Even the cosmic and gamma rays are within the bounds of this phase of chemistry. B. C. H.

Problems in Radioactivity. S. C. LIND. *Chem. Bull.*, **15,** 319 (Nov., 1928).—The writer cites several unsolved problems in radiochemistry. These he divides into two general classes: those which we hope to solve without any further knowledge of the nucleus than is now possessed, and those involving the inner structure of the nucleus.

Some of the problems included in the former class are: the determination of the branching point of the actinium family; a knowledge of the isotopes of uranium and of thorium; transmutation of atoms; the location of elements 85 and 87; the discovery of elements of higher atomic weight than uranium.

In regard to the latter class, the author does not believe a knowledge of the structure of the nucleus can be gained very rapidly by studies based upon bombardment of the nucleus with alpha particles. This structure he considers may be more attainable by deductive studies using the vast amount of various radioactive data now available. E. L. M.

The Story of Sugar from Flowers. H. E. BARNARD. *Home Economist*, **6,** 286 (Oct., 1928).—Honey is a natural sugar, unrefined, untreated, and unchanged as it comes to the table from the forms in which it was stored by the bees. It also contains small quantities of phosphates, lime, iron, and traces of vitamins. It is apparently sweeter to the taste than any other commercial sugar, due to its distinct aroma and flavor. It is a fuel producing food. Being a mixture of levulose and dextrose, it does not have to be inverted in the body and is immediately available to the blood stream.

Many suggestions are given for its use in cooking, etc., in place of sucrose. J.W.H.

Utah's Beet-Sugar Industry. A. S. TAYLOR. *Compressed Air Mag.*, **33,** 2587–90 (Nov., 1928).—Nearly 6 million tons of sugar are used annually in the U. S. of which 1/4 is supplied from domestic sources. Three-quarters of the domestic sugar comes from beets. Utah ranks third among our states in the production of beet-sugar. The process used, starting with sugar beets and leading to granulated sugar, is outlined in some detail. A brief history of the industry in Utah, since the Mormons attempted to introduce it in 1851, is included. The article is well illustrated and should be of interest to students competing in the A. C. S. Prize Essay contest. E. R. W.

HISTORICAL AND BIOGRAPHICAL

New Pasteur Memorial. *Hygeia*, **6,** 707 (Dec., 1928).—A description with photograph of the monument to Pasteur recently dedicated in Chicago. An account of the ceremony is also included. M. W. G.

Harry Nicholls Holmes. *Crucible*, **12,** 176 (Dec., 1928).—Portrait and short biographical note. M. W. G.

Joseph Priestley, The Clergyman-Scientist. *Laboratory*, **1,** No. 5, 67–8 (1928).—A few notes on Priestley, with photograph of the Priestley Memorial Museum at Northumberland. G. B. C.

Leo Hendrick Baekeland. L. V. REDMAN. *Ind. Eng. Chem.*, **20,** 1274–5 (Nov., 1928).—An account of Dr. Baekeland's career in creative industry. M. W. G.

Lucius Pitkin. E. B. MAYO. *Ind. Eng. Chem.*, **20,** 1275–6 (Nov., 1928).—An intimate account of Dr. Pitkin's abilities and achievements. M. W. G.

Svante Arrhenius. OSSIAN ASCHAN. *Finska Kemistsamfundets Medd.*, **36,** 66–75 (1927); *C. A.*, **22,** 4283 (Nov. 20, 1928).—Biography with portrait. M. W. G.

Memorial Address on Justus von Liebig. F. HABER. *Z. angew. Chem.*, **41,** 891–7 (1928); *C. A.*, **22,** 4016 (Nov. 10, 1928). M. W. G.

Alessandro Volta. TEOFILO ISNARDI. *Anales asoc. quim. Argentina*, **25,** 391–417 (1927); *C. A.*, **22,** 4016 (Nov. 10, 1928). An address. M. W. G.

EDUCATIONAL MEASUREMENTS AND DATA

A Study of General Science Textbooks. A. M. HEINEMAN. *Gen. Sci. Quart.*, **13,** 11–23 (Nov., 1928).—There are many textbooks in the field of general science. What is lacking in these as satisfying to the majority of teachers? Since principles are the foundation of a science, what importance has been accorded principles in the various textbooks? A principle in the terms of the study was taken to mean a statement of relationship between two or more facts. The author studied twenty textbooks and found the percentage of principles to vary from 12.11% in Clute (1917) to 1.10% in Trafton (1920). The older books generally make the better showing in principles. It is probable that more recent books have emphasized the practical needs of pupils. It is increasingly recognized that the individual, rather than the subject, should be taught. Over 2000 applications to life-situations were found and classed as explained problems, inference problems, and exercises.

"Although general science textbooks are numerous, the results of this study would indicate that a book built on principles is yet to be written. Such a book would be in accord with the definition of a science, and were it enriched with applications to life situations, it might meet a real need of the general science teacher."

"It would be difficult to estimate the value of a course of study that left clear cut in the pupil's mind ten or twelve well-defined principles for each science represented. Each science could then build upon the results achieved by the previous science. Continuity, the absence of which is charged to be the serious lack in science, would be made possible." J. H. G.

An Experimental Investigation of the Relative Effectiveness of Two Plans of Supervised Study. HARL R. DOUGLASS. *J. Educ. Res.*, **18,** 239–45 (Oct., 1928).—The purpose of the experiments described was to determine the relative efficiency of the sequence of supervised study preceding recitation as compared to the sequence of recitation preceding supervised study.

Past practice has favored the sequence of study following recitation in the belief that the study of material to be recited immediately after is not as likely to result in permanent learning as study with a view to retention for at least 23 1/2 hours; and further, that a recitation immediately following study is not as adequate a test of learning as one held on the following day.

Two factors are formed that seriously impair the efficiency of supervised study: (1) in the time following recitation, pupils are not inclined to study as seriously as they

will for a recitation looming ahead in the next period; (2) where the recitation-study sequence is used the recitation is frequently run over into time theoretically allotted to study. Thus, the lengthened period has not proved much advantage over the short period where no supervised study is contemplated.

The argument for study preceding recitation consists in the utilization of the increased interests of pupils, making certain that the time theoretically allotted to supervised study is actually realized.

The experimental groups consisted of ten pairs of classes in a six-year junior-senior high school, covering work in history, civics, English, mathematics, and science. The students were paired in respect to chronological age, Otis Intelligence Test scores, and an achievement test.

Results were measured by objective tests. The author finds the study-recitation sequence better for classes in history, social studies, and literature, whereas the recitation-study sequence is more effective for classes in mathematics and science.

In those classes where effectiveness of study does not depend so directly upon specific assignments better results will follow the use of the study-recitation sequence: (1) due to the higher level of attention immediately preceding recitation, (2) the student has made a beginning of preparation, located his difficulties, and is in a receptive attitude toward assistance.

In mathematics and science classes study should follow the presentation of new material while explanations and directions are fresh in mind.

In subjects involving memory the recall and repetition within the next hour, as in the study-recitation sequence, will serve to fix the material before the setting in of the rapid decline in the forgetting curve gets under way.

R. M. P.

THE METHODS AND PHILOSOPHY OF EDUCATION

Creating a Curriculum for Adolescent Youth. *Res. Bull. N. E. A.*, **6**, 1–79 (Jan., 1928).—An extensive survey of the junior high school in the United States, including summaries of research concerning work at these grade levels; many tables, charts, bibliographies. S. R. P.

The Place of Theory in Education. W. D. ARMENTROUT. *Teachers J. & Abstr.*, **3**, 446–52 (Sept., 1928).—A well-reasoned answer to the criticism that teacher-training programs contain too much theory and not enough practice.

Just as in earlier times heat and sickness were thought of as "things," so also was mind considered a thing. Mind in terms of activities and functions, learning conceived as modification of behavior, a complex nervous system making many responses possible and resulting in the need for readjustment and reorganization—these concepts have changed the philosophy and consequently the practice of education. Educational aims are bound up also with the question of values in human life as well as with the nature of mind. The place of science and statistics is that of finding out what the results of education are. Philosophy is the search to determine what educational agencies should desire or attempt to achieve. There is thus constant evaluation and provision for growth.

Most any teacher can profitably consider such a presentation of the importance of philosophy in education. S. R. P.

A Study of the Disciplinary Problems and the Method of Handling Them as Practiced in the Senior High School. JOHN F. PIERCE. *Teachers J. & Abstr.*, **3**, 509–15 (Oct., 1928).—The summary of an unpublished master of arts thesis, Colorado State Teachers College, Greeley, Colorado, 1927. Problem: What problems of discipline are there? Which are most significant? How and by whom are such problems handled? Study made of 150 representative schools throughout the United States. Results given chiefly in tables.

Conclusions: not all problems are significant; problems of discipline can be met by different methods of control, including student coöperation; in general, the greater the student participation in extra-curricular activities, the fewer the disciplinary problems. S. R. P.

Are Our High Schools, Colleges, and Universities Meeting Present-Day Requirements? DAVID SNEDDEN. *Educ. Admin. & Superv.*, **14**, 451–60 (Oct., 1928).—Attendance at these schools is rapidly increasing. There is no general agreement as to what present-day requirements are. Following these remarks, the author critically considers the questions: Does a college education pay? What is the aim of education? Is the function of the agricultural college as clearly defined as that of the medical school? What is the future of the liberal arts college? Can there really be "generalized" education? Are vocational high schools shams? What are the shortcomings of the Amer-

ican high school? In conclusion he formulates a brief summary of his answers. In all, a thoughtful and thought-provoking analysis of educational conditions. S. R. P.

The American Alternative to Examinations. E. C. OAKDEN. *Educ. Outlook*, **80,** 349 (Nov., 1928).—Some interesting impressions of a British visitor contrasting college "credits" in America with the comprehensive examinations in English institutions, together with his views on new-type tests. S. R. P.

The Principal Studies His Job. *Res. Bull. N. E. A.*, **6,** 82–147 (Mar., 1928).—An extensive analysis of the functions of school administrators, with full bibliographies on various phases of the subject. S. R. P.

The Teaching of Science. L. B. AVERY. *Gen. Sci. Quart.*, **13,** 40–4 (Nov., 1928).—There are at present three acknowledged divisions in the teaching of science in the public schools:—*science*, from which is omitted any study of astronomy or geology; *general science*, which has been struggling to find itself for the last ten years or more, but has not yet arrived at any clear definition; and *nature study*, an older phase of science teaching. These are rarely clearly separated by the teacher. General science comes between the other two and has been aimed to meet the prevailing ignorance of things scientific through various methods. The following seven seem adequate channels around which the phenomena of applied natural forces may be grouped:—health and sanitation; shelter and clothing; food; lighting; heat; communication; transportation. The function of general science is not to establish the field of any particular science, but to open clear pathways to all of them. J. H. G.

A College Course in General Science. M. KENNEDY. *Gen. Sci. Quart.*, **13,** 9–10 (Nov., 1928).—General science has hardly yet been accorded a place on the level with other sciences in the high school. A more recent development however is the teaching of general science in colleges and universities under various titles such as orientation course, survey course, general science and others. Under the latter title a course was offered, as an experiment, at the State Teachers College of Farmville, Va. in the junior and senior years. The class met twice a week for lecture and once a week for a two-hour laboratory period. "The Nature of the World and of Man" was used as a textbook. In the spring quarter the students were given time and opportunity to do special reading and a little original research work on some selected topic. The two-hour laboratory course was almost entirely a methods course. A high-school course in science was outlined and this was used in the general science class of the college training school. Teachers were prepared to teach general science in high school. Some of the results obtained were: an understanding of the importance of general science, and a greater enthusiasm for teaching science. J. H. G.

Measurement and Experimentation in Educational Methods. V. A. C. HENMON. *J. Educ. Res.*, **18,** 185–94 (Oct., 1928).—In this critical study of experimentation the author shows "that our measurements are too imperfect to base a true science of education or a methodology upon them, that our experiments are too inadequately controlled, and that educational processes are so complex that our relatively simple experiments are incapable of revealing them. When we bear in mind that these experiments are carried out in the laboratory, and *not* in schools and under school conditions, the inconclusiveness of them is the more apparent and the difficulties of interpretation and application become all the greater."

Gregor Mendel established the science of genetics, not because he was an intellectual giant, but rather that he had the brilliant idea of simplifying his experiments to the point where he was dealing with only one or two variables at a time. He followed one character through many generations, thus obtaining results so simple that he was able to give them their correct interpretation. To make real progress in educational experiments we must learn the lesson of controlling variables, taking them up one by one, and carrying them through long-time, large-scale investigations.

The author advocates the establishing of research institutes in each of the school subjects for the direction of experiment and the dissemination of information. We have reached the stage where we realize that problems are not solved by theorizing nor by appointing committees and taking votes. Neither can we rely upon sporadic experiments by teachers and by research students. As matters now stand those who are most capable of making these investigations are swamped by teaching and administration, and constructive research languishes. R. M. P.

A Study of a Modified Form of the Multiple Response Test. FRANCIS D. CURTIS. *J. Educ. Res.*, **18,** 211–9 (Oct., 1928).—The modified form consists of the conventional form with a blank added after each exercise, the pupils being instructed to underline the correct response if it is found among those given, or if not given, to write it in the blank provided.

The summary of results shows that the modified form is more difficult than the conventional multiple response. It requires more time to correct and score, though it requires very little, if any, longer than the conventional form to administer.

It is as good as the conventional form in that: (1) it takes no longer to construct; (2) it differentiates between the good and the poor pupils; (3) it is probably as valid; (4) it is as reliable. The modified form is superior in that: (1) it has greater value for diagnosis of individual and class difficulties and weaknesses; (2) it stimulates more thinking on the part of the pupil while taking the test; (3) it eliminates whatever guessing factor may operate in the multiple-response. R. M. P.

Creative Thinking. LUELLA B. COOK. *J. Educ.*, **108,** 35–6 (1928).—Creative thinking may be stimulated by (1) making assignments which permit a wide variety of solutions; (2) making assignments which require that judgment function more than memory; (3) placing emphasis upon skill rather than definitions. R. A. B.

THE PHILOSOPHY OF SCIENCE

The Language of Science. W. A. NOYES, JR. *Chem. Bull.*, **15,** 329 (Nov., 1928).—The text of the article is based on Lavoisier's statement in his "Traité Elementaire de Chimie," written in 1793: "The impossibility of isolating nomenclature from science and science from nomenclature results from the fact that all science is formed necessarily of three things: the series of facts which constitute the science; the ideas which they call forth; the words which express them."

The writer emphasizes the truth contained in the above statement and criticizes rather severely the authors of scientific papers who use terms in other than their correct form. He states: "A fact which is not yet fully understood is that the writing of scientific articles is of as great importance as the doing of the research." E. L. M.

Interpretation of Research. BENJAMIN T. BROOKS. *Sci. Mo.*, **27,** 410–5 (Nov., 1928).—Research must usually be interpreted. The world at large, and especially the business man interested in technical progress, and the youth, groping about for a career, is entitled to know what is happening and what are the trends of research and its significance. B., therefore, condemns the zealous exaggerator. The proper interpretation of science, however, can do a great deal in inspiring youth with the ideals of science and zeal for research. While it is believed that elementary students should be occasionally led to the mountain top, to a high point of vision so that they may see all the beauty and supreme importance of scientific endeavor, they should at the same time know that only by a great deal of hard work can they fit themselves to participate in the glory of the great achievement. G. W. S.

THE TEACHING PROFESSION

Grading the Professor. R. S. *Sch. & Soc.*, **28,** 311–4 (Sept. 15, 1928).—The value of a professor to an institution may become known to college authorities through his being graded by the students and such a system, if taken seriously, should stimulate teaching methods.

According to the author, students are not, as a rule, prejudiced as is frequently thought. Professors who have a knowledge of their subject, the ability to make their subject interesting, and a sense of reliability are graded as being good teachers.

The ideal teacher, or faculty-politician as the author calls him, is a young bachelor who through his interest in all student affairs and his sympathetic attitude will be popular with the students and because of this popularity will be regarded as indispensable to the institution and so rapidly advanced. K. S. H.

The Advancement of the Professional Training of Teachers. WILLIS L. UHL. *Wash. Educ. J.*, **8,** 8–9 (Sept., 1928).—Dean Uhl sets forth a few principles which seem to underlie the advancement of the professional training of educators. *First,* sound scholarship precedes the professional knowledge of subject matter. *Second,* a critical study of the meaning of human progress is a requisite for educators. *Third,* the interrelation of educational influences is dependent upon a knowledge of representative human institutions. *Fourth,* the financing of schools is dependent upon an informed citizenry. *Fifth,* the arousal of pupils to educative activities is the central problem of educators. *Sixth,* educators must adopt the procedures of science to the problems of education. *Seventh,* educators, like their own pupils, learn by doing. *Eighth,* educators must know and apply the best knowledge and practices of their profession. *Ninth,* educators are pupils for life. *Tenth,* the success of schools of education depends upon the success of educators in general. A. E. C.

Tentative Plan for New State Retirement Fund. S. E. FLEMING. *Wash. Educ. J.*, **8,** 16–7 (Sept., 1928). A. E. C.

Good Chances for Long Life. REVIEW. *Ohio Teacher*, **49**, 115 (Nov., 1928).—A report of the summary of health conditions among teachers in the United States as given by the Metropolitan Life Insurance Company. S. R. P.

Practices Affecting Teacher Personnel. *Res. Bull. N. E. A.*, **6**, 206–55 (Sept., 1928).—Includes consideration of requirements affecting appointment, retention, and promotion of teachers, practices affecting professional improvement, salary schedules, relation of salaries to training and efficiency, with tables of data and bibliographies. S. R. P.

How to Apply for a Teaching Position. H. W. JAMES. *Educ.*, **49**, 138–42 (Nov., 1928).—From a summary of replies to a questionnaire sent to 189 superintendents in Alabama and 67 superintendents in the other 47 states the author advocates the following suggestions to teachers making application for positions.

1. The first letter should be brief, to the point, and contain all essential information. 2. The help of a mutual friend is very advantageous. 3. The letter should be in legible script. 4. The applicant should probably not take the initiative in mentioning salary. 5. A photograph should be enclosed with the first letter. 6. There is not as good a chance of securing a position in your home locality as in a different one. 7. The best method of getting in touch with a vacancy is by writing direct to superintendents or through the recommendation of the college attended. 8. In giving references, school officials with whom you have taught are the best and college authorities rank next. 9. A personal interview is desirable whenever possible. G. B. C.

"Standards" and the Teaching Load in Sciences. M. A. C. *Science*, **68**, 339 (Oct. 12, 1928).—Various educational standardizing agencies of the country have stipulated the maximum teaching load of teachers under their jurisdiction. Where classroom instruction and laboratory supervision are specifically mentioned it is the rule to give to one classroom period a weight equal to that of two periods of laboratory work.

The American Council on Education has made no such distinction and "..... any general assumption that the burden of laboratory teaching is less hour for hour than the burden of teaching of other types is utterly wrong."

"Discrimination against the teacher of a science through under-valuation of his services in the laboratory is unjust to the teacher, unfair to his pupils, and unfavorable to that development in teaching of sciences which the times demand. It is time that scientists should bring this situation to the attention of standardizing agencies and of school and college authorities in positive fashion and should exercise their influence in such ways as may be necessary to remove the handicap under which no small portion of their number are laboring." G. H. W.

The Training of Science Teachers. FLORENCE BILLIG. *High-Sch. Teacher*, **4**, 332–3 (Oct., 1928).—Specialists are best prepared to suggest the outstanding contributions of science, *i. e.*, its important conceptions and generalizations.

These conceptions and generalizations of most consequence in liberal thought and practical affairs of everyday life are to be made the core of the curriculum in science. In the training of the science teachers these selected conceptions should be "clarified and made acceptable."

The teacher in training should be aided in realizing the "basic oneness of all science." Such training should eliminate the organization of school science about but single phases of science.

The training course for prospective teachers of science: (1) should provide for a core content for the grade levels for which the teacher is in preparation; (2) should provide marginal material for elaborating the core material; (3) should include the best of classroom methods for developing science materials; (4) should stimulate the ones in training to make the acquaintance of their environment and to utilize it in achieving the goal of their school science work. B. C. H.

MISCELLANEOUS

What Is Wrong with the United States? THOMAS JEFFERSON WERTENBAKER. *Scribner's*, **84**, 433–40 (Oct., 1928).—Aroused by the flood of criticism, just and unjust of the United States, the author arises to its defense. He points out that conditions in the past necessitated the development of American agricultural resources, followed by an industrial revolution which has made this country lead the world in production, largely due to the invention of labor-saving machinery which, by releasing workmen, has advanced human welfare.

In medical research, the country has done a very important work. Advances in aeronautics and exploration have opened up new worlds. In the strictly cultural aspect, much has been accomplished in painting, literature, architecture, and political science.

In pure science the psychologist, J. McKeen Cattell, states: "It is my general impression that the United States is in advance of Great Britain and Germany in the biological and geological sciences and in astronomy, behind them in physics, chemistry, and physiology, and about on even terms with them in mathematics." Professor Joseph Mayer of Tufts College, in the January *Scientific Monthly*, states: "In the last hundred years the United States, France, Great Britain, and Germany have each produced more than thirty outstanding scientists, while no other country has produced more than six." T. B. D.

Something for Nothing. WILLIAM HOSKINS. *Am. Mag.*, **106**, 43 (Nov., 1928).—William Hoskins, a distinguished chemist tells, in this interview, how scientific fakers have cashed in on the credulity of people who hope for quick riches. Numerous and various illustrative examples are given. Advice is given to those who are planning on making an investment in some scientific scheme. E. L. M.

Measuring Atomic Layers Step to Better "Talkies." Layers of metallic rubidium, only one atom deep, so thin that several million would be required to equal the thickness of the paper this is printed on, have been measured at the Bell Telephone Laboratories in New York. Thin films of rubidium, a metal similar to the sodium of common salt, are important because of their use in photoelectric cells.

As the magic lamp of modern physics, the photoelectric cell, transmuter of light variations into sound, is the very heart of the revolutions in industry that have been plotted in the physics laboratories. Talking motion pictures, radiovision, television, telephoned photographs would all be impossible without the photoelectric cell.

In the course of researches on how to make the photoelectric cell most efficient, A. L. Johnsrud measured the thin films. When the thin film of metal inside the glass cell was very thin it operated better than when thicker. Rubidium can be made into thin films more easily than its relative metals, because at rather low temperatures and without loss of time it can be made to evaporate and the vapor deposited, in a vacuum, to form such a film.

A large photoelectric cell was made and so arranged that rubidium could gradually be deposited on the glass, or else, after a thick deposit had been made, it could gradually be removed. While the film was thus getting thicker or thinner, the photoelectric response, the current given off when light fell on it, could be measured. Since the maximum response was obtained at the same point, whether the film was growing thicker or thinner, it was necessary exactly to record the film's depth.

Ordinary measuring methods proved inadequate and polarized light was used. Polarized light differs from ordinary light because, by passage through a special kind of prism, it is made to vibrate in a single direction. Ordinary light waves vibrate up and down, right and left, and in every conceivable direction, but that of polarized light is confined to a single plane.

When polarized light passes through any film, such as the one of rubidium, the direction in which it vibrates is twisted. The thicker the film, the more it is twisted. By means of another prism similar to that which polarizes the light the extent of the twisting, and also the thickness of the film, is measured. The most current was obtained when the film was but one atom thick.—*Science Service*

Chemist Finds New Way to Preserve Ether. Ether, which is widely used as an anesthetic during operations, may now be stored for as long as eight months without spoiling or deteriorating, S. Palkin and H. R. Watkins reported at the Swampscott meeting of the American Chemical Society. This valuable substance, which has made possible the triumphs of modern surgery, does not keep well in the pure state. The two chemists have found a way to preserve ether without making it less pure, using either of two preservative agents, pyragallol or permanganate, which do not in any way affect the other properties of ether.—*Science Service*

Local Activities and Opportunities

Through these columns, the JOURNAL desires to render a two-fold service.

1. **Local Activities.** Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. **Opportunities.** Providing an exchange column for positions. That is: (1) any teacher who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed, however, the necessity for such action will be largely obviated.

West Virginia University. On Wednesday, November 28, 1928, John Roscoe Turner was inaugurated as the tenth President of West Virginia University.

Dr. Turner, a native West Virginian, has attained distinction in the field of economics, and at the time of his election to the Presidency, was Dean of Washington Square College, New York University, to which position he had risen since obtaining his Ph.D. from Princeton in 1913.

The inaugural procession formed at the Circle of the University Campus at 2.00 P.M., and marched to the new University Field House, where the formal exercises were held. In the procession were the entire cadet band and cadet corps, the university faculty and representatives from 142 colleges, universities and learned societies wearing full academic costume, two ex-presidents of the University, University officials, the State Board of Control, The University Board of Governors, several distinguished visiting educators, and the Hon. Howard M. Gore, Governor of West Virginia.

In his inaugural address, which drew frequent and hearty applause from the audience of 6000 people, President Turner committed himself with the backing of the Board of Governors, to the establishment of a Graduate School at the University. West Virginia has untold natural resources and the new policy of the University will be to prosecute research work intensively in the fields of chemistry, engineering, and geology.

In connection with the inaugural ceremonies, the Northern West Virginia Section of the American Chemical Society had as its speaker on Tuesday evening, Dr. S. W. Parr, President of the American Chemical Society. The subject of Dr. Parr's address was the "Processing of Coal." On Wednesday morning various university group meetings were held, one of these being a meeting of chemists, engineers, and geologists before which addresses were delivered by Dr. Parr, Dexter S. Kimball, Dean of the School of Engineering, Cornell University, David White, Senior Geologist, United States Geological Survey. At this meeting, Dr. Clark, head of the department of chemistry at West Virginia University, stated that his departmental faculty, although burdened with extremely heavy undergraduate and graduate teaching duties, have collectively published 98 articles in scientific and learned publica-

tions, and at present have three such articles accepted for immediate publication. The chemistry department, now housed in a splendid new $800,000 building, anticipates with much pleasure the privilege of certifying candidates for the Ph.D. degree in the near future.

Dickinson College. Dr. H. L. Davis has returned to Cornell University for special research work with Professor Bancroft. His successor is Mr. C. C. Bowman.

Dr. E. A. Vuilleumier, head of the department of chemistry, has been appointed dean of the freshman class.

University of Buffalo. Mr. H. Milton Woodburn, instructor in analytical chemistry, has received leave of absence to complete his work for the doctor's degree at Northwestern University.

The fourth edition of "Experiments on the Non-Metals," by Long, Chamberlin, and Buckley has been published. Dr. Buckley is assistant professor of organic chemistry at the University.

Dr. Riegel, professor of industrial chemistry, has issued his new book on "Industrial Chemistry," which has been reviewed in the *Industrial and Engineering Chemistry*, on page 276, and in THIS JOURNAL, **5**, 1709 (Dec., 1928).

Physical Sciences Club of the university is made up of people whose mutual interest in these sciences has drawn them together for the purpose of discussing scientific subjects. The membership includes not only physicists, chemists, biologists, physiologists, astronomers, and other scientists from the staff, but an even greater number of workers in these fields from the industries of the Niagara frontier. Most of the discussions are handled by the members, and relate to researches which they are conducting or to papers which they have had occasion to study.

University of Pittsburgh. The department of chemistry of the University of Pittsburgh announces three special summer courses for graduate study and for those interested in college instruction or industrial laboratories. The courses follow:

S 127. **Chemical Microscopy**—dealing with the use of the microscope in chemical practice. This course will be given under the direction of Dr. E. V. Hjort, and begins July 29, 1929, covering four weeks.

S 135. **Quantitative Organic Microanalysis**—affording laboratory practice in the quantitative analysis of minute amounts of organic substances. This will be under the direction of Dr. R. T. K. Cornwell. The course begins July 2, 1929, and lasts four weeks.

S 249, 250. **Theory of Solutions**—a study of the thermodynamic properties of solutions, the Debye-Hückel Theory and its applications. Dr. A. L. Robinson will be in charge. The course begins July 2, 1929, and lasts eight weeks.

As the demand for the courses in chemical microscopy and microanalysis will probably be quite heavy, it may be necessary to run two sessions, one beginning July 2nd and the other July 29th. Those interested are asked to apply early to secure a preference in a particular group.

Northwestern University. Two of the lectures recently given on this campus were of sufficient interest to those interested in chemical education to deserve note. Both were arranged and sponsored by the local chapter of Phi Lambda Upsilon.

Prof. Kendall of the Medical College presented a paper before the Nov. 30th meeting of the Journal Club, entitled "The Formation of Alcohols by Bacteria." Various theories to account for the interesting reactions were discussed critically and experimental work suggested. An interesting discussion as to modes of attack followed the formal presentation of the paper.

A public lecture by Prof. H. S. Taylor, on "Chemistry, the Handmaiden of Industry," Dec. 8th, was well attended, and aroused much interest among the undergraduates as well as among those more

familiar with the subject matter. Dr. Taylor discussed science in respect to its relation and increasing practical application to commercial problems. He maintained that chemistry, more than any other science, held a position of supreme importance to industry.

The Pennsylvania State College. Dr. Ralph T. Cornwell, assistant professor of chemistry at the University of Pittsburgh, gave a very interesting and helpful talk on "Quantitative Organic Microanalysis" at the December meeting of the Central Pennsylvania Section of the American Chemical Society.

The technic of microanalysis is apparently quite new in this country and Dr. Cornwell is helping materially in the advancement of this important field of analytical chemistry.

Dr. Charles H. Herty, Jr., Supervising Metallurgist of the Bureau of Mines, Pittsburgh, addressed the Penn State Mining and Metallurgical Society on Tuesday evening, December 11th, on the subject, "Science in the Iron and Steel Industry." Dr. Herty's work on the applications of physical chemistry to the open hearth process of steel manufacture is of the greatest importance.

On January 7, 1929, Dr. Hubert Alyea, National Research Fellow at the University of Minnesota, gave an address on "Negative Catalysis" before the Central Pennsylvania Section of the American Chemical Society. Dr. Alyea's paper on this subject presented at the Institute of Chemistry at Evanston last summer was considered one of the best papers of the Institute.

At another meeting of the Central Pennsylvania Section on January 17th, Dr. E. W. Allen, Director of the Office of Experiment Stations, United States Department of Agriculture, Washington, D. C., will speak on the subject "Problems in the Organization of Research." This lecture will be given under the auspices of the School of Agriculture.

Columbia University. Professor T. C. Taylor addressed the Vermont section of the American Chemical Society at the University of Vermont on December 5th, on the chemistry of starch.

C. E. Braun, Ph.D., Columbia 1925, has been appointed assistant professor of organic chemistry at the University of Vermont.

Wisconsin State Teachers' Association, Chemistry Section. The Chemistry Section of the Wisconsin State Teachers' Association had its annual meeting in Milwaukee, November 9th. Ninety-four members were present. Prof. John C. Hessler, of Knox College, Illinois, read a paper on "What Chemistry Should Every Adult American Know?" and Prof. J. H. Mathews, of the University of Wisconsin, gave an illustrated lecture on "Scientific Methods Used in Detecting Crime."

The officers of the past year were: A. P. Minsart, *Chairman*, Wausau; Isabel Henkel, *Secretary*, Milwaukee; Vera Templin, *Contributing Editor*, Baraboo. The new officers elected are: T. A. Rogers, *Chairman*, Teachers' College, Stevens Point; Eleanor Cox, *Secretary*, Baraboo; M. J. W. Phillips, *Contributing Editor*, West Allis. J. H. Mathews was re-elected *Senator*.

New England Association of Chemistry Teachers. The 113th Meeting of the N. E. A. C. T., was held Saturday, December 15, 1928, at the New Harvard Chemical Laboratories, Oxford Street, Cambridge, Mass. The program was as follows:

MORNING SESSION—10.30

Inspection of New Harvard Chemical Laboratories.

AFTERNOON SESSION—1.15

Business Meeting.

Report of Secretary.

Report of Treasurer.

Reports of Committees.

New Apparatus—Charles Wells, Alton W. Bush, Raymond H. Parker, Harriett A. Rugg, Georgenia Kerr.

Current Events—Edwin T. Peterson, Almon E. Deane, Margaret C. Brawley, L. Clyde Cook, Mary L. Mudgett.

New Books—Hazel W. Holt, Harlan P. Shaw, Helen A. Thayer, M. Barbara Dee, Henry D. Colton.

Industrial Trips—O. J. McGaffigan, Francis D. Whittemore, Edward W. Ellsworth, Ralph H. Houser, Ralph B. Delano.

Address, "Microscopy as an Adjunct in the Teaching of Chemistry," by Professor E. M. Chamot, Department of Chemistry, Cornell University.

Address, "New Views on Acids and Bases," by Dr. Norris F. Hall, Harvard University.

South Dakota Education Association, Science Section. The South Dakota Science Section of the S. D. E. A. met at Mitchell from November 26th to 28th, inclusive. The program presented was as follows:

Theme: *Content Plus Method in Teaching Science.*

"Questionnaire Study of North Central Association Schools," by J. H. Clouse, Sioux Falls.

"Relation of Chemistry to Agriculture," by Jack Ready, Aberdeen. (American Chemical Society National Prize Essay.)

"Adaptation of the General Science Course to Local Needs," by Arthur Schmidt, Lead.

"Some Unusual Lecture-Demonstration Experiments in High-School Chemistry," by A. L. Haines, Vermilion.

"A Combined Laboratory and Classroom for High School," by J. H. Jensen, Aberdeen.

"The Chemistry Library Reference Section," by Ralph E. Dunbar, Mitchell.

"A New Method for Producing Standing Waves," by David L. Cook, Madison.

"The Historical Viewpoint of Teaching Beginners the Classifications of Compounds of Inorganic Chemistry," by A. M. Pardee, Vermilion.

"Garvan Prize Essay Contest," by H. A. Dunbar, Brookings.

"Catalyzing Student Reactions with Atomic Structure," by D. C. Farley, Brookings.

Leader of Informal Discussion—H. B. Mathews, Brookings.

The group met for a business luncheon in the dining room of the Episcopal Church on Tuesday noon, November 27th, at which time fifty-one guests were served.

Industrial excursions were made the last day of the session to the plants of the Equity Creamery Co., Reierson Bakeries, Northwestern Public Service Co., and The Gurney Greenhouse Co. This feature of the program was under the direction of Miss Mildred Redman, of Mitchell. Dakota Wesleyan University joined with the science classes of Mitchell High School in preparing a most extensive science exhibit of student material, texts, industrial materials, standardized tests, magazines, teacher's reference books, government bulletins, and demonstration apparatus.

Officers elected for the next year include Carl G. Watson, Rapid City, *President;* J. H. Clouse, Sioux Falls, *Vice-President;* Ralph E. Dunbar, Mitchell, *Secretary-Treasurer;* A. L. Haines, Vermilion, and David L. Cook, Madison, *members of the Executive Committee.*

Florida Section, A. C. S. The twentieth meeting of the Florida Section, A. C. S., was held in Tallahassee, Florida, on Saturday afternoon and evening, November 24th. The program was as follows:

"The Future of Agricultural Chemistry in Florida," by Dr. R. E. Ruprecht, Head, Chemistry Department, U. S. Experiment Station, Gainesville, Fla.

"The Mineral Resources of Florida," by Mr. Herman Gunter, Florida State Geologist, Tallahassee, Fla.

"The Work of the State Chemist's Office," Mr. Gordon Hart, Assistant State Chemist, Tallahassee, Fla.

"Visions," by Dr. John N. Swan, Head,

Department of Chemistry, University of Mississippi, Oxford, Miss.

Between the afternoon and evening sessions the Scientific Society of the Florida State College for Women were hosts of the section at a delightful banquet served in the university dining hall.

Officers were elected for the new year as follows:

Chairman—Dr. R. S. Bly, Head, Department of Chemistry, Southern College, Lakeland, Fla.

Vice-Chairman—Dr. L. J. Lewis, Head, Department of Chemistry, Florida State College for Women, Tallahassee, Fla.

Secretary-Treasurer—Dr. R. C. Goodwin, Department of Chemistry, University of Florida, Gainesville, Fla.

Councilor—Dr. F. H. Heath, Department of Chemistry, University of Florida, Gainesville, Fla.

Senators of Chemical Education—All reelected.

Lexington Section, A. C. S. The 130th regular meeting of the Lexington Section of the American Chemical Society was held in Kastle Hall, University of Kentucky, 4.00 P.M., Tuesday, December 11, 1928. Major O. R. Meredith spoke on "Chemical Warfare."

The Cincinnati Section, A. C. S. The 302nd regular meeting of the Cincinnati Section of the American Chemical Society, was held in the Chemical Auditorium of the University of Cincinnati on December 12, 1928, at 8.00 P.M.

The speaker of the evening was Dr. H. N. Alyea, National Research Council fellow in the department of chemistry of the University of Minnesota. His subject was "Chain Reactions and the Mechanism of Inhibition."

Dr. Alyea told about some of the recent important developments in the field of negative catalysis. His was truly a scientific subject which was readily comprehended and of common interest to chemists in widely varying fields.

Outstanding work in this field has been carried out during the past few years at Princeton University and at the Nobel Institute in Stockholm. It has been Dr. Alyea's good fortune to have been associated with Professor Hans L. J. Bäckström at both institutions, with Professor H. S. Taylor at Princeton, and to continue the same line of work with Professor S. C. Lind at Minnesota.

"Ultra-Violetted" Cereal Now Offered on the Market. A cereal food treated with ultra-violet light to give it the beneficial action of vitamin D, preventive of rickets, has now appeared on the market. This is the first commercial application of the discovery of the famous University of Wisconsin professor, Harry Steenbock, that ordinary foods exposed to the action of ultra-violet rays, either from quartz lamps or from natural sunlight, will promote the formation of healthy bones and teeth in children and young animals, supplementing or sometimes even supplanting the usual cod-liver oil.—*Science Service*

Sicilians Save Volcano Snow for Summer Use. The Sicilians who live on the slopes of Mt. Etna have never heard of refrigeration engineering, yet they regularly make use of one of its basic principles, the use of porous, light material as a heat-insulating blanket. And they use this principle, oddly enough, to exploit the snowbanks that form in an extinct crater of this great fire-mountain in winter. They cover the snow with ashes, which effectively prevents the heat of the sun from melting it until late in the summer. Then they shovel it out into sacks for transportation to the city of Catania, where it is used in the manufacture of ice cream.—*Science Service*

Recent Books

A Laboratory Manual of General Chemistry. LEON B. RICHARDSON AND ANDREW J. SCARLETT, JR., Professors of Chemistry in Dartmouth College. Henry Holt and Company, New York, 1928. vi + 57 pp. 13.5 × 21 cm. $0.90.

We are familiar with two extreme types of laboratory manuals. In one, numerous short experiments of a descriptive nature are outlined with little or no discussion of the principles of chemistry. In the other type there are only a few experiments outlined and they are of either a quantitative nature or in some other way designed to develop the theoretical side of the subject.

This manual is made up of a very good combination of descriptive experiments and experiments of a nature such as to aid the student in an understanding of the theories of chemistry. There are a total of fifty-four exercises planned, many of which are made up of a number of short tests of the "test tube" type. The first three are directions for glass working, measurements of gas volumes, and weighing. The students' time is conserved by the inclusion of blank pages for notes and tables for the recording of data. The manual was prepared to accompany "General Chemistry" by Richardson, and numerous references to the text are made.

The directions are clear and concise, but are rather abrupt. The reviewer would prefer that directions for an experiment be prefaced with a brief discussion which would suggest to the student a reason for performing the experiment. No such introductory matter is included by the authors. Their method is to give directions and then ask questions on the significance of the results.

The consecutive order of the exercises may perhaps best be designated as "conventional," unless one considers the placing of the experiments with sulfur before those dealing with chlorine an exception. Ionic equilibria and solubility products are well emphasized in the experiments with the metals.

SHERWIN MAESER
UTAH AGRICULTURAL COLLEGE

Chemical Calculations. J. S. LONG, Ch.E., M.S., Ph.D., AND H. V. ANDERSON, B.Ch.E., M.S., Lehigh University. Second edition. McGraw-Hill Book Co., New York, 1928. ix + 227 pp. 11 figures. 20 × 13.5 cm. $1.75, postpaid.

This is a second edition of a book which first appeared in 1924. It consists of fifteen chapters, dealing with such problems as thermometric calculations, density of solids and liquids, gas laws (including Dalton's law of partial pressures), definite and multiple proportions, Gay-Lussac's law of combining volumes, gram-molecular-volumes, derivation of formulas, balancing of oxidation-reduction equations by change in valence, normal solutions, gas analysis, thermal equations, electrolysis, mass law, and solubility products. The appendix contains tables of data useful in solving the problems. Each chapter contains a brief discussion of principles, followed by ample lists of numerical problems, with and without answers. In the preface the authors state that these problems were originally designed for use in the second half of the freshman year, using weekly recitations. The lists of problems appear large enough to furnish a supply for three or four years' work, without repetition.

The exercises are well chosen, and appear to be arranged with a view to increasing difficulty. They show as much variety of form as might be expected. The numerical quantities used are seldom

whole numbers, and the calculations might be unduly laborious unless logarithms or slide rules are used.

The discussion of how much work of this kind should be included in the freshman course is outside of the scope of a book review. However, there are many of us teachers who believe that the use of problems of this sort requires of the student closer thinking and a deeper understanding of the mathematical relations of chemistry than can be obtained in any other way, and who will extend to the book a warm welcome.

J. H. REEDY

UNIVERSITY OF ILLINOIS

Introductory Qualitative Analysis. JACOB CORNOG, Assistant Professor of Chemistry at the State University of Iowa, and WARREN C. VOSBURGH, Assistant Professor of Chemistry at Duke University. The Macmillan Co., New York City, 1928. ix + 155 pp. 3 figs. 21.5 × 14 cm. $1.60.

This book is intended for a short course in Qualitative Analysis occupying "thirty clock hours" of laboratory work. A very short course indeed.

The book is divided into two main parts. The first deals with laboratory directions and explanations (100 pp.); the second with the theory of analytical reactions (42 pp.). The second part might as well form part of a different book for little use is made of it in the laboratory directions. While the author's opinion is that "the acquisition of theoretical insight is not a result of simple volition, of persistent effort, or of memory on the part of the student" but that "it has its genesis in an inquiring intellectual attitude," the reviewer fails to see how this "inquiring intellectual attitude" can be stimulated by telling the student one thing in the laboratory part and proving that same thing to be wrong in the theoretical part.

He is told (p. 67) that "lead ion unites with chromate ion to give a precipitate of lead chromate," and the solubility product is quite fully discussed in the theoretical part. He is told (p. 64) that "the addition of a base will cause the removal of hydrogen ion because hydrogen and hydroxide unite to form water:

$$H^+ + OH^- \longrightarrow H_2O$$"

and then hydrolysis is scientifically though briefly discussed on page 126. Examples could be multiplied.

There is no mention of dissociation constants in the book and if the student is supposed to have become familiar with their meaning in a previous course there seems to be no necessity for devoting page 19 to the antique definitions of acids and bases.

The book could be much improved by distinguishing in the laboratory part between essentials and explanatory notes. The latter should have been written in smaller type. Many pages could have been saved and the following of the directions made easier to the student. Such superfluous directions as asking the student to become familiar with "the location of drinking water and toilets" (p. 1) and "when the test is completed, the solution and the precipitate can be thrown away" (p. 60), are out of place in a work intended for college men.

A serious error occurs on page 62. Nickel does not replace *two* hydrogens from *one* molecule of dimethyl glyoxime but only *one* from each of *two* molecules. The formula of the precipitate is not $NiO_2N_2C_4H_6$, as given, but $Ni(O_2N_2C_4H_7)_2$. This would be an unfortunate idea to instil in the mind of a future analytical chemist.

Although much may be said about the theoretical part, which is ably written, the laboratory part contains nothing new, much that is old and discarded, as, for example, the separation of magnesium from calcium with ammonium carbonate, and the book cannot be recommended as a whole for a serious course in qualitative analysis.

J. E. ZANETTI

COLUMBIA UNIVERSITY

Elements of Qualitative Chemical Analysis. W. W. SCOTT, Sc.D., Professor of Chemistry, University of Southern California. D. Van Nostrand Company, Inc., New York City, 1928. viii + 164 pp. 10 figures. 10 × 14.5 cm. $1.60.

Until recently there have been two general types of textbooks on qualitative analysis. One type makes the matters of tests and separations the sole end of the course, and completely ignores the great underlying principles. The other type goes to the opposite extreme, and makes the subject simply a series of applications of "mass action" and other physico-chemical laws. Scott, in his manual, takes a middle ground. The analytical procedures are well developed, yet simple and direct; on the other hand, the theoretical explanations are by no means neglected.

The groupings and separations are, in general, the customary ones. For example, Group III includes both the amphoteric hydroxides and the sulfides, and the two subgroups of Group II are separated by ammonium polysulfide.

Each group is treated under three heads: *preliminary tests*, *separations*, and *chemical principles*. Under *preliminary tests* are given the comparative reactions of the elements, with particular reference to separations and tests. These are all laboratory experiments, which the student himself performs. The *separations* are given in tabular form, and are very complete. Following these tables in each case is a chart, summing up in diagrammatic form the steps of the analytical processes, also giving the formulas, colors, and solubilities of the precipitates formed.

Under *chemical principles* is given a thorough study of the changes involved in the separations and tests—a good theoretical discussion, but not too hard for a first-year college student.

At the end of each group is a "classroom review"—a set of questions and problems intended to clinch the students' knowledge of the subject matter. This list of questions is followed by a list of equations covering all the chemical changes involved in the group.

In Part II the acid ions are treated in the usual way, and in Part III is given *systematic analysis*, with complete directions for preparing the solution, dealing with refractory substances, etc. Part IV gives very complete information about preparing reagents and test solutions. At the end is an appendix containing tables of blow-pipe tests, and flame tests, also "Identification of Substances by Their Crystal Form." The introduction covers manipulative details, some of which are new and interesting.

W. H. CHAPIN

OBERLIN COLLEGE

Analytical Chemistry. Vol. 2. Quantitative Analysis. F. P. TREADWELL, late Professor of Analytical Chemistry at the Polytechnic Institute of Zürich, and WILLIAM T. HALL, Associate Professor of Analytical Chemistry, Mass. Inst. of Technology. Seventh edition. Wiley & Sons, Inc., New York City, 1928. xiii + 848 pp. 152 figures. 15 × 23.5 cm. $5.00.

The seventh edition of this well-known and valuable book, while retaining almost the same page numbers, contains a number of important changes and additions based upon recent work. Among these may be mentioned improved procedures for the separation and determination of magnesium, phosphate, calcium, titanium in steel, beryllium, bismuth, lead in brass, manganese, chromium and vanadium in steel, and the use of potassium acid phthalate as a standard for alkali. Fifty-four pages are devoted to general operations, 386 to gravimetric analysis, 186 to volumetric analysis, and 82 to gas analysis. There are a number of important tables useful to chemists, including density and chemical factors. A feature of the new edition is a syllabus of a course in quantitative analysis as given to chemical engineering students at the Massachusetts Institute of Technology.

There are a number of methods of recognized merit not mentioned, which might well be included, such as Fales' method for precipitating zinc sulfide, the phenylhydrazine method for separating aluminum from iron and other metals, the precipitation of palladium by dimethylglyoxime, Starck's method of determining fluorine, titration of vanadic acid with ferrous sulfate, and the use of constant boiling hydrochloric acid as a primary standard in acidimetry. The excellent work of Smith on the perchlorate method for potassium is not even mentioned, although it represents a great improvement in the accuracy of this popular process. Because this book is not only a text but a reference book, it is desirable that it should include as many such recognized methods as possible.

The preparation of cupferron on page 160 might well be omitted because this reagent has been on the market for some time.

Few errors appear; a rather obvious one occurs on line 6 from the bottom of page 86, where "calcium oxalate" should be "ammonium oxalate." It is obviously incorrect, on page 594, to assume that iron wire has a purity of 99.7%.

This book includes very little theory and is primarily one of methods and procedures. It should be in the library of every analytical chemist, and available to every student of quantitative analysis.

H. H. WILLARD
UNIVERSITY OF MICHIGAN

Elementary Practical Physical Chemistry. FRANK SHERWOOD TAYLOR, M.A., B.Sc., Chemistry Master at Gresham's School, Holt, England. Oxford University Press, American Branch, New York City, 1928. xi + 128 pp. 51 figures. 12.5 × 18.75 cm. $1.25.

The book "has been written for the use of the advanced classes of schools and the first-year classes of the universities"(English schools are meant). For the average American college it would serve quite well for students in the third year or, in exceptional cases, for those of the second year.

The book presents in a clear manner the necessary details for the laboratory work in a course of *elementary* physical chemistry; the directions call for very simple apparatus, most of which may be found in the ordinary small college laboratory or which may be constructed by one of ordinary ability. The topics are, in general, well selected to impress the student with the viewpoint that physical chemistry "is not a special kind of chemistry," but rather a summarizing recognition of the general laws underlying all chemical phenomena. For this reason it is urged that the study of physical chemistry be begun at the beginning of the college course—a point of view adopted in part, at least, by an increasing number of teachers of freshman chemistry in American colleges.

The topics for laboratory determination include molecular weights; the ionic hypothesis in relation to color, heat of neutralization, common ion effect, indicators, electromotive force, etc.; reaction rates; distribution; heterogeneous equilibria; and some behaviors of colloids. Some valuable numerical tables and suggested experimental problems are found at the end of the book.

The author has succeeded in presenting his material in a clear-cut manner. No difficulty should be experienced by the average student in following directions. Sixty-three exercises are presented; none are long.

The book appears to be teachable. It offers an opportunity to small colleges to carry out some practical physical chemistry hitherto not attempted, perhaps, on account of lack of funds. For those colleges and universities more fortunately situated financially, the rather pertinent suggestion is made not to wait until the third or fourth year to present the quantitative side of some of the simple physico-chemical problems of this book. Though it is not expected that the regular laboratory course in physical

chemistry of the average American university would be aided materially by the use of this text, the reviewer is inclined to suggest that some physico-chemical experiments might be introduced into the curriculum much earlier than is usually done. This text would serve well for such purposes. W. A. FELSING

UNIVERSITY OF TEXAS

Molecular Rearrangements. C. W. PORTER, Professor of Chemistry, University of California. American Chemical Society Monograph Series No. 45. The Chemical Catalog Co., Inc., 419 Fourth Avenue at 29th Street, New York City, 1928. 166 pp. 3 figures. 15 × 23 cm. $4.00.

This monograph attains the purpose of the series in presenting an intelligible review of molecular rearrangement reactions with sufficient illustrations and discussions of proposed reaction mechanisms to stimulate further research in this prolific field.

An idea of the scope and contents of this monograph may be found in the following summary of its chapters (I–VII) as to their subject matter, respective number of pages covered, and the respective number of references (bibliography) to work cited therein: I. Migrations from Carbon to Nitrogen, 45 pp., 118 references; II. Migrations from Nitrogen to Carbon, 28 pp., 68 references; III. Migrations from Carbon to Carbon, 29 pp., 94 references; IV. Migrations from Oxygen to Carbon, 6 pp., 17 references; V. Migrations between Oxygen, Nitrogen, and Sulfur, 20 pp., 39 references; VI. Metatheses Involving Rearrangements, 4 pp., 8 references.

Concerning the mechanism of molecular rearrangement reactions, the author states that "there is substantial evidence of more than one step in the conversion of a compound into an isomeric form. In many cases, however, the reactions seem to be due to the direct exchange of places between two atoms or groups within a single molecule. Many chemists refuse to accept this idea. They are unwilling to assume that such a reaction can occur within a single molecule . . . . Those who oppose the theory of direct exchange of groups within an isolated molecule seem to have no difficulty in accounting for similar exchanges between atoms or groups in different molecules. Yet to accomplish a double decomposition, a collision between two molecules is a necessary antecedent. Every metathesis is an example of this type. Existing bonds must be broken and new ones established in either case. Of the two types of reactions, the author regards the reaction within a single molecule as the simpler process, for in this case the reaction groups are carried along together."

In the furtherance of simplicity, in depicting the mechanism of reactions, it is gratifying to note that the author does not complicate structural formulas by imposing upon them the shared electron and cubical octet systems of valence notation which are calculated to confuse rather than elucidate. He preferably uses the simple plus and minus signs throughout the book since they no longer imply complete polarity. "They indicate only relatively positive and negative states" and this is all that is required for an electronic representation of the Hofmann rearrangement (viewed in the light of the Stieglitz univalent nitrogen theory) and other reactions.

A noteworthy feature of the monograph, serving to stimulate interest and research, is the presentation of many dilemmas met in the literature descriptive of rearrangement reactions and interpretations thereof. The following quotation (p. 43) presents a double dilemma in that it involves not only a special investigation, but also a typical sample of editorial comment equally baffling to authors of papers.

"There is at present no agreement with respect to the importance of Lachman's observation [relating to rearrangements in aqueous solution]. One of his papers, when submitted for publication,

was read by two referees and returned by both of them with recommendations for revision; one claimed, "the assumption that the compound can be dehydrated in dilute aqueous solution is so novel that further evidence in support of the claim should be presented," the other said, "there is nothing new in the idea that dehydration of such a compound can be accomplished in aqueous solution."

The style is direct and clear, the reactions discussed are amply illustrated by equations, there are few typographical and formula errors, and the author has fulfilled his purpose "to review the more important types of rearrangement, to classify them on the basis of structural similarities, to present the principal theories relating to mechanisms, and to supply an extensive bibliography."

Any student contemplating or engaged in molecular rearrangement research can hardly afford to be without a copy of this monograph, even though its cost is $4.00. It is worth more but unfortunately does not sell for less.

H. SHIPLEY FRY

UNIVERSITY OF CINCINNATI

Textbook of Chemistry for Nurses and Students of Home Economics. ANNIE LOUISE MACLEOD, Professor of Chemistry and Director of Euthenics, Vassar College. The McGraw-Hill Book Co., New York City, 1928. Second edition. xiii + 241 pp. 14 × 20.5 cm. $2.50.

It is the purpose of this textbook of chemistry to serve as a guide for lecture and laboratory work in the training of students of nursing and of home economics. In a brief way the author has covered most of the subjects which occur in the General Treatises of College Chemistry: in addition there is included a brief summary of some outstanding subjects, such as metabolism, digestion, and assimilation, which are peculiar to the field of physiological chemistry. A series of 22 laboratory experiments is included, the aim of which is to familiarize the student with the manipulation of the chemist, and acquaint her with some of the characteristic reactions in physiological chemistry.

It is, indeed, of special interest to note that although this textbook is intended for students to whom chemistry is not a major study, the author has opened the subject with a rather comprehensive discussion of atomic structure and the latest theories regarding chemical constitution. One of the outstanding characteristics of the book is the style of the author, which is one of a popular and easy-reading nature, containing numerous everyday, practical illustrations which are familiar to the student nurse. It is unfortunate, in the mind of the reviewer, that this text, as most other texts on chemistry intended for nurses, omits a discussion of certain salts of the metals intended for medicinal purposes, which compounds are constantly being used by the nurses, and a familiarity with which is therefore desirable. In the chapter on physiological chemistry, work is given for the detection of glucose by means of Fehling's solution. However, the most modern method of using Benedict's solution for this purpose is not discussed.

This text on chemistry covers the general field included by other texts of a similar nature, and devotes much space to the discussion of the fundamental concepts of matter and energy.

JOHN C. KRANTZ

UNIVERSITY OF MARYLAND

Textbook of Biochemistry. A. T. CAMERON, M.A., D.Sc. (Edin.), F.I.C., F.R.S.C., Professor of Biochemistry, Faculty of Medicine, University of Manitoba. Foreword by Professor Swale Vincent, Professor of Physiology, University of London. First edition. The Macmillan Company, New York City, 1928. x + 462 pp. 2 plates + 12 figures. 13.5 × 20.5 cm. $5.50.

This textbook is based entirely on lectures given by the author for a number of years to students of medicine who have already had fundamental training in both physical and organic chemistry.

After presenting an introductory chapter dealing with the present-day concept of biochemistry, a brief review of the theoretical aspects of catalysis reactions in biochemical change and a review of the significance of pH, the author then plunges into a discussion of the chemistry of his subject under the following chapters.

(*a*) *Food-Stuffs, Their Derivatives and Related Substances.* Here is given a brief review of our present-day ideas regarding carbohydrates, lipoids, and proteins.

(*b*) *The Chemistry of Digestion, the Circulation, and the Excreta.* A review of the importance of bacteria, chemical activity in lower organisms, and the chemistry of blood, respiration, and excreta.

(*c*) *Intermediate Metabolism.* Including a review of the chemistry of tissues, intracellular synthesis, products of intermediate metabolism, and the vitamins.

(*d*) *The Chemistry of Reproduction; The Chemical Controlling Agencies of the Organism.* A review of the agents governing and coördinating metabolic processes.

(*e*) *Quantitative Metabolism.*

(*f*) *Addenda.* A brief review of the present status of the chemistry of immunology and the importance of biochemical processes utilized in industry and their introduction to pharmacy.

As might be predicted, the author has only touched upon elementary features of a very broad and rapidly growing field of science. The subject matter embraced under the term "Biochemistry" has today assumed such proportions that an author is called upon to exercise much skill in selecting chapters suitable for a condensed text of this character. The author has, however, done quite well, and has contributed a sequence of data which should be stimulating to a medical student interested in following up research in this science. It is not a book that follows the ordinary logical procedure usually associated with such texts, and the author has adopted a dogmatic treatment which is really stimulating. The text will, undoubtedly, serve a useful purpose. The author's work reveals to the student in medicine that the subject of biochemistry no longer presents confusion, and he is made to see a definite picture of the chemical processes of life and death.

TREAT B. JOHNSON
YALE UNIVERSITY

Colloid Chemistry. THE SVEDBERG, Professor of Physical Chemistry, University of Upsala. American Chemical Society Monograph Series No. 16. Second edition. Revised and enlarged in collaboration with Arne Tiselius, Research Assistant in Physical Chemistry, University of Upsala. The Chemical Catalog Company, Inc., New York City, 1928. 302 pp. with 167 figures. 15 × 23 cm. $5.50.

In this, the second edition of the well-known monograph of Professor Svedberg, the author has attempted to give a general survey of colloid chemistry. The book has been considerably enlarged over the first edition, which contained 250 pages of subject matter. Forty pages of text have been added while there are fifty-two additional figures. A fine description of the ultra centrifuge as used by the author in his colloid investigations features the new edition. The value of x-ray analysis in this field and the recognition of the importance of Donnan potentials constitute the principal additions to the subject matter. The usefulness of the book has been much increased by giving references to the original work in footnotes on the respective pages, instead of placing the complete bibliography at the end of the book.

Following a short introduction and history of the subject one finds the content of the book divided into four parts as follows:

I. *The Formation of the Colloid Particle.*

II. *The Colloid Particle as a Molecular Kinetic Unit.* In this section are discussed the size and shape of the particle as well as its Brownian movement.

III. *The Colloid Particle Regarded as a Micell.* Under this heading the particle

is considered with its surrounding field, its absorbed ions and molecules.

IV. *The Aging and Destruction of the Colloid Particle.* Because of the scarcity of information in this field one page only is devoted to this subject.

The author logically develops his subject from the standpoint of the colloid particle as the central point in colloid chemistry. From this point of view the book is perhaps the best presentation of the subject which we have. Investigations carried out in the author's laboratory constitute the chief part of the experimental work used to illustrate the text. One thus obtains a rather complete picture of the investigations of Professor Svedberg. The teacher of chemistry who has a knowledge of physical chemistry will be able to acquire a fine picture of the field of colloid chemistry. More and more teachers of chemistry will find it to their advantage to understand the fundamental principles of this field.

L. H. REVERSON
UNIVERSITY OF MINNESOTA

Sekai Kwagaku-shi (Universal History of Chemistry). ROKURO NAKASEKO (in the Japanese language). Kaniya Book Store, Kyoto, Japan, 1927. v + 571 pp. 31 photogravure plates. 14 × 21.7 cm. Price, 6 yen.

The present review relates to a book which the "reviewer" has under his hand and wishes keenly that he were able to read. Let it serve to call attention to the beautiful volume—and to the evidence which it supplies of a growing interest in the history of chemistry. The book covers the whole history of chemistry and contains thirty portraits of eminent chemists, of whom seven are Japanese and two are American (Ira Remsen and Russell H. Chittenden). Describing as it does the classic researches of chemistry, it will surely supply an enormous stimulus to chemical study and research in Japan. The first section, pp. 1–106, deals with the history of chemistry in Japan, the second, pp. 107–158, with the history of Chinese chemistry, and the two make the book more complete than any which is available to Occidental students. We should like to know more—much more—about the history of chemistry in Japan and China. It is good to know that something is in print on the subject, though printed in Japanese. Let us hope that the author will some day supply us with an English translation—or, better yet, with a book devoted to an even fuller treatment of the history of Japanese and Chinese chemistry.

An excellent review of the book by Muccioli is published (in Italian) in *Archivio di Storia della Scienza*, **9**, 379–82 (1928).

TENNEY L. DAVIS
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BOOKS RECEIVED—LIBRARY OF CONGRESS, NOVEMBER 15 TO DECEMBER 15, 1928

Avalle, Edoardo, I combustibili liquidi per i motori endotermici. Processo della combustione—Combustibili liquidi derivati dalle sostanze vegetali—Gli alcooli come carburanti—Combustibili liquidi dai carboni fossili, dalle ligniti, torbe, asfalti, bitumi e schisti. Il processo Bergius. Processo di cracking. Milano, C. Tamburini fu Camillo, 1928. xiv, 407 p. incl. illus., tables, diagrs. pl. 25 cm.

Badger, Walter Lucius and E. M. Baker, Inorganic chemical technology. 1st ed. New York, McGraw-Hill Book Company, Inc., 1928. vii, 228 pp. incl., illus., tables, diagrs. 23½ cm. $2.50.

Boord, Cecil Ernest, Laboratory outlines for organic chemistry. Columbus, The Ohio State University Press, 1928. 52 pp. 23 cm.

Bradbury, Robert Hart, Laboratory studies in chemistry to accompany the rev. ed. of A first book in chemistry. New York, D. Appleton and Co., 1928. xii, 198 pp. incl., front., illus. 19½ cm.

Bragg, William Henry, An introduction to crystal analysis. London, G. Bell and

Sons Ltd., 1928. vii, 168 pp., illus., VIII pl., diagrs. 22½ cm.

Burn, Joshua Harold, Methods of biological assay. London, New York, H. Milford, Oxford University Press, 1928. xvii, 126 pp., illus., diagrs. 22½ cm.

Daalen, Cornelis Koert van, Bijdrage tot de kennis van de chemische en botanische samenstelling van het hooi en van den invloed, welke enkele mest-stoffen daarop uitoefenen. Utrecht, P. den Boer, 1928. 5 p. l., 187 pp. 24½ cm.

Farnsworth, Marie Anna, The theory and technique of quantitative analysis. New York, J. Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1928. 2 p. l., iii–vii, 154 pp., illus., diagrs. 24 cm. $2.50.

Green, Stanley Joseph, Industrial catalysis. London, E. Benn, Limited, 1928. xi, 507 pp., illus., diagrs. 25 cm.

Gruber, Joseph, Contribution à l'étude des liopoïdes. Paris, M. Vigné, 1927. 33 p., 1 l. 25½ cm.

Guilliermond, Alexandre, Clef dichotomique pour la détermination des levures, par A. Guilliermond. Paris, Librairie Le françoise, 1928. 124 pp., illus. 19½ cm.

Hackh, Ingo Waldemar Dagobert, Chemical reactions and their equations; a guide for students of chemistry. 2nd ed., rev. Philadelphia, P. Blakiston's & Sons Co., 1928. x, 145 pp., illus. 20 cm.

Kingzett, Charles Thomas, Chemical encyclopaedia, an epitomized digest of chemistry and its industrial application. 4th ed. London, Baillierè, Tindall and Co., 1928. viii, 807 pp., diagrs. 23 cm.

Lamborn, Leebert Lloyd, Modern soaps, candles and glycerin, a practical manual of modern methods of utilization of fats and oils in the manufacture of soap and candles, and of the recovery of glycerin. 3rd ed., 2nd printing. New York, D. Van Nostrand Company; London, C. Lockwood & Son, 1920. xx, 688 pp. incl., front., illus., diagrs. pl. 24 cm.

McPherson, William, Wm. E. Henderson, and Wm. L. Evans, Laboratory manual arranged to accompany the 3rd ed. of "A course in general chemistry." Boston, New York, Ginn and Company, 1928. vii, 165 pp., illus. 24 cm.

Ohmann, Otto, Die unfallverhütung im chemischen und physikalischen unterricht als grundlage der unfallverhütung in haushalt und technik. xvi, 203 pp., illus. 19 cm.

Partington, James Riddick, The compositions of water. London, G. Bell and Sons, Ltd., 1928. vi p., 1 l., 106 pp., illus., vi pl. (incl. port., 2 facsim.) on 4 l. 18½ cm.

Porter, Charles Walter, Molecular rearrangements. New York, The Chemical Catalog Company, Inc., 1928. 167 pp. diagrs. 23½ cm. (American chemical society. Monograph series. No. 45).

Rischbieth, Paul, Quantitative chemische versuche; übungen für den gebrauch an hochschulen und höherer lehranstalten. viii, 155 pp., illus., diagrs. 19 cm.

Rumeau, G., Cours de chimie, à l'usage de la classe de mathématiques spéciales et des candidats aux grandes écoles. Paris, Delagrave, 1928. v. diagrs. 25½ cm.

Sackur, Otto, Lehrbuch der thermochemie und thermodynamik. Berlin, J. Springer, 1928. xvi, 347 pp., illus., diagrs. 24 cm.

Settimj, Luigi, Gomme, resine, gommoresine e balsami; origine—produzione—composizione e usi industriali dei principali prodotti vegetali di secrezione. Milano, U. Hoepli, 1909. 3 p. l., xvi, 373 pp., illus. 15½ cm.

Smith, Donald Pritchard and H. K. Miller, An introduction to qualitative chemical analysis and the related chemical principles. 1st ed. New York, McGraw-Hill Book Company, 1928. xii, 275 pp., incl., illus., tables, diagrs. 21 cm. $2.25.

Smith, Harold Manton, A study of the less volatile oils in Salt Creek (Wyo.) crude. Washington, U. S. Govt. Print. Off., 1928. ii, 28 pp. incl., 1 illus., tables, diagrs. 23 cm.

Thieme, Johann Gottfried, Studies on sugar boiling. New York, Facts about Sugar, 1928. 1 p. l., 116 p. illus., diagrs. 23 cm.

Winslow, C. E., A. and A. F. Dolloff, Relative importance of additive and antagonistic effects of cations upon bacterial viability. A. F. Dolloff, Baltimore, 1928. pp. 67–92., diagrs. 25½ cm.

Congresso nazionale di chimica pura ed applicata. *2d, Palermo,* 1926. Atti del II° Congresso nazionale di chimica pura ed applicata, Palermo e Sicilia, 22 maggio i giugno 1926. Roma, Associazione Italiana di Chimica generale ed Applicata, 1926–27. 3 v. illus., ports. of groups, maps, diagrs. 26 cm.

Symposium on colloid chemistry. *6th, University of Toronto,* 1928. Colloid symposium monograph; papers presented at the Sixth Symposium on Colloid Chemistry, University of Toronto, June, 1928, edited by Harry Boyer Weiser. New York, The Chemical Catalog Company, Inc., 1928. 346 pp., illus., diagrs. 24 cm.

U. S. Bureau of Standards. Relations between rotatory power and structure in the sugar group. Washington, Govt. Print. Off., 1926. v tables. 26½ cm.

U. S. Bureau of Standards. United States government master specification for powder, scouring, for floors. Federal specifications board specification no. 34 a. (Revision promulgated May 22, 1928. Supersedes F. S. B. Spec. no. 34.) Washington, U. S. Govt. Print. Off., 1928. 6 pp., 24 cm. (Circular of the Bureau of Standards, No. 370.)

U. S. Bureau of Standards. United States government master specification for trisodium phosphate, technical (phosphate cleaner). Federal specifications board specification no. 558. Washington, U. S. Govt. Print. Off., 1928. 5 pp. 23 cm. (Circular of the Bureau of Standards, No. 369.)

U. S. Interdepartmental committee on paint specification standardization. United States government master specification for oil, linseed, raw. Federal specifications board specification no. 4 b. (Revision promulgated April 30, 1928. Supersedes F. S. B. Specification no. 4 a.) Washington, U. S. Govt. Print. Off., 1928. 8 pp. 26 cm. (Circular of the Bureau of Standards, No. 361.)

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Instrument Measures Paint Color. Hit-and-miss methods of mixing paints will soon be replaced by mathematical methods when the results of an investigation into the strength of pigments used in making tints completed by the U. S. Bureau of Standards are put into practical use. The Bureau has measured with the spectrophotometer the color value of 104 different mixtures of pigments combined with a standard color.

The investigation has disclosed the exact strength and amount of a pigment that should be mixed with a standard color to bring a given result. The investigation is hoped to result in a numerical color value being given to each pigment instead of the mixture depending on more or less uncertain methods of comparing shades.—*Science Service*